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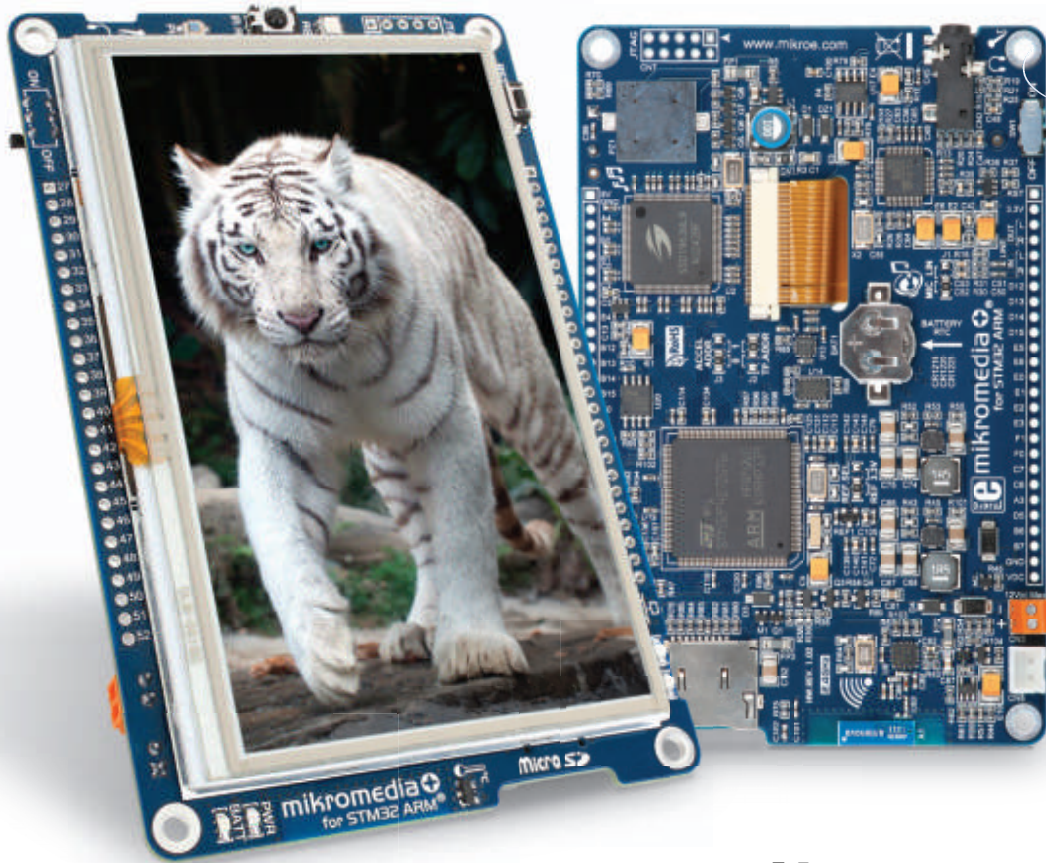
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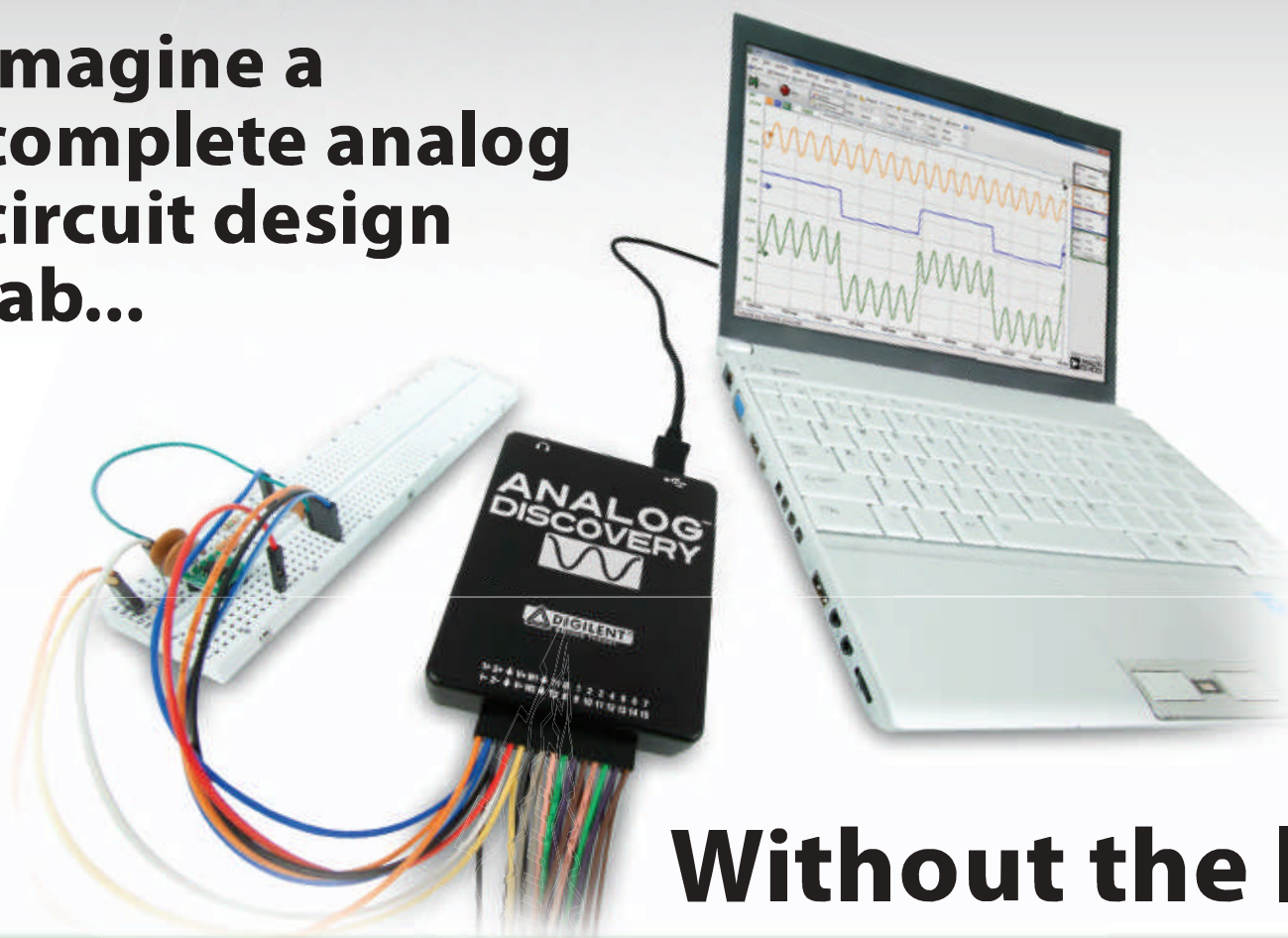


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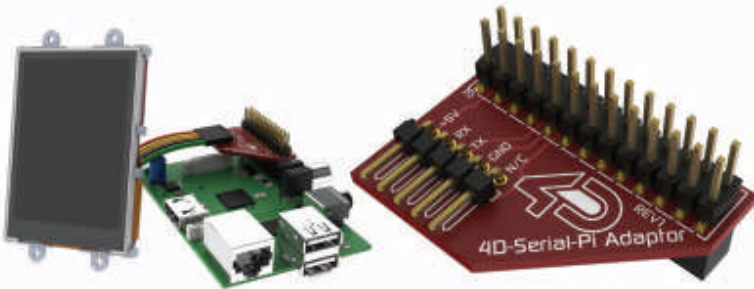
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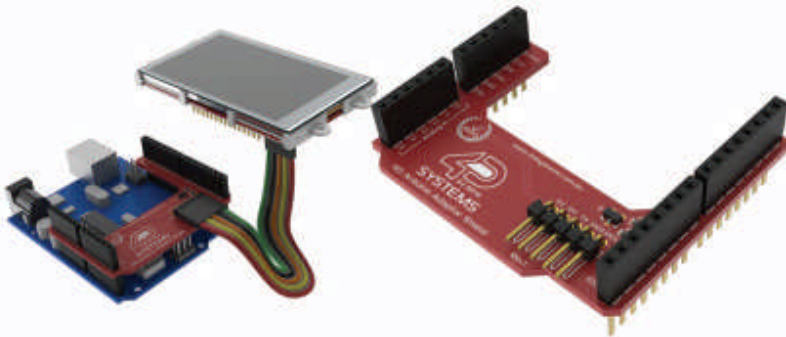
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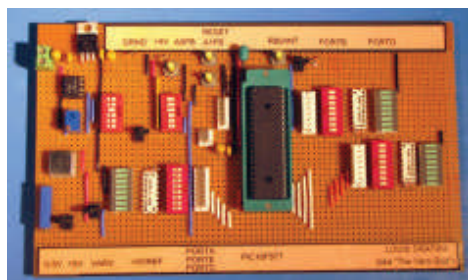
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Events, Advances, and News

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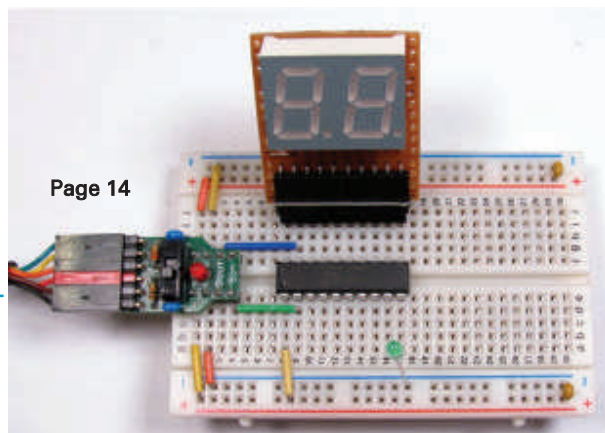
This simple electronic version of a photocell makes it convenient to do lighting control without the use of the sun.

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Programming • Hardware • Projects

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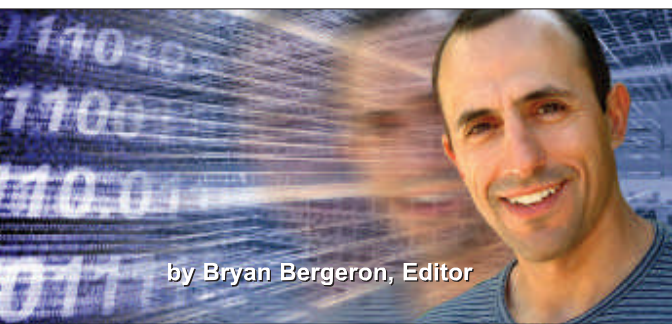
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by Bryan Bergeron, Editor

DEVELOPING PERSPECTIVES

The Duality of Technology

The bombings at the Boston Marathon were a human tragedy, with the deaths, hundreds physically injured, thousands psychologically affected, and an entire metropolitan area disrupted. They also served to illustrate the duality of technology.

For example, the suspects apparently used simple RF triggers to detonate the two pressure cooker bombs near the finish line. The circuit was apparently simple enough that any *Nuts & Volts* reader could assemble one in an afternoon with instruction from the Internet. That same communications technology has not only transformed how we interact and do business, but saves thousands of lives annually.

At least for the time being, the bombings have focused the public's attention on the responsible use of technology. There are renewed discussions, for example, on policing the Internet. Should anyone be allowed to post the schematic of a remote detonator on the Internet? Should providers block such content, just as they do in other countries?

The Internet seems inherently different from a print publication, where censorship (editorship) is the norm. For example, within the past year, I rejected a manuscript from an overseas author that detailed how to use a cell phone for a remote trigger to an unspecified device. Sure, it could have been used to start a car, but I decided the

potential for harm was too great. As print publications move online, does the role of editorship somehow change? Are there liability issues?

There is also a change in perception on the use of surveillance. A month before the bombings, the talk around Boston was of banning surveillance cameras from public places — whether fixed or on drones. Post bombing, the public sentiment seems to have shifted to allow drones and fixed cameras in all public areas for both deterrence and to assist in identifying suspects.

Digital imaging and Internet technologies were certainly instrumental in the eventual capture of the surviving suspect. There was the crowd-sourced effort to identify the two suspects based on a pool of uploaded images. There were also the amazing IR images of the suspect hiding in the boat that probably saved the arresting officers from injury.

Will every major city in the US move toward the approach exercised in London, where thousands of cameras cover every street in the city? Will we go even further and allow police drones free access to city streets and perhaps even outlying areas? It's too soon to tell, but it's certain that a technological response to the bombings is inevitable. At issue is how we — as a society — balance the duality of technology so that we both enjoy our freedom and have some degree of protection against those who might cause us harm. **NV**



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READER FEEDBACK

(Un)MATCHED PAIRS OF TUBES

I just got caught up on some of my reading yesterday, and have a story about matched pairs you might find amusing; it's a memory triggered by your March editorial. Fifty years ago when I was in high school, we had a decent — for the time — stereo system powered by two Dyna Mark IIIs, which took KT88s. My brother insisted we buy matched pairs, so we got them from a company whose name was something like Gold Lion. Whatever kind of "lion" they were, they may also have been lying.

The spec sheets that came with each tube — with their little red check marks for each tested specification — were a perfect match, check inflection to check inflection. In fact, when my brother reordered another pair a couple years later, the spec sheets were identical to those of the earlier tubes (yes, I kept those spec sheets for reference).

I had no way to tell if the tubes were matched because — back then — I only had a simple good-bad vacuum tube tester.

My brother and I were also both hams at the time, and I later went into stereo repair at the dawn of the transistor era with soldiers coming back in droves from Vietnam, with stereo equipment from Japan in tow.

(A childhood and current friend of mine still has his Sansui system that he brought back with him).

I segued out of electronic repair at the dawn of the integrated circuit era as repair became must less challenging to me, and got into microprocessor system design and programming. I segued out of that into custom computer system programming, which I stayed in until I retired a few years ago.

I have a lifetime subscription to NV, which I cherish. Is there another magazine that even comes close to supporting the electronic hobbyist?

Although my tinkering days are over, I do enjoy reading the design articles and keeping up with the latest in μ P technology. I will probably never (in reality) lick a Stamp or take a Propeller for a spin, but I do so vicariously in your pages. Keep up the great work.

Steve Borsher

Thanks for sharing. I guess human nature hasn't changed much in the past 50 years. My first real experience with tubes was with a Heathkit DX60B transmitter (6146A tube). I had other tube-type equipment before then, but I really learned to know the tube.

Peak the grid and dip the plate ...

If there's something you think we should cover (more tubes?), please let me know.

Bryan Bergeron, Editor

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COMPARE & SAVE

ADVANCED TECHNOLOGY



■ Howard Chen, developer of the multi-arm bioprinter, works to build multicellular structures.

PRINT ME A PANCREAS, PLEASE

Somewhere within the University of Iowa (www.uiowa.edu) lies the Center for Computer Aided Design, within which exists the Advanced Manufacturing Technology (AMTech) group. The group was formed to design, create, and test a variety of electromechanical and biomedical components, systems, and processes that will help to revive manufacturing activities in the US. The group is working on projects ranging from automotive and aviation printed circuit boards, but possibly the most interesting research area relates to replacement parts for damaged and failing human organs and tissue. The fascinating aspect is that the researchers — rather than working with harvested organs — are endeavoring to create living, multi-cellular body parts using a multi-arm 3D printer and "bio-ink."

According to co-director Ibrahim Ozbolat, "One of the most promising research activities is bioprinting a glucose-sensitive pancreatic organ that can be grown in a lab and transplanted anywhere inside the body to regulate the glucose level of blood." The key is the multi-arm printer design that allows several materials to be printed at the same time. That way, one arm can be printing blood vessels while the others create tissue-specific cells that the vessels link.

"The long-term goal of this branch," noted the other co-director, Tim Marler, "is to create functioning human organs some five or 10 years from now. This is not far fetched." Ongoing research is supported by the National Institutes of Health, the Electric Power Research Institute (EPRI), and other groups. ▲

SUBCUTANEOUS CHEMISTRY LAB

For many people, the old Cole Porter tune, "I've Got You Under My Skin," is just a charming old love song. Some of us — being perhaps slightly tomophobic — find it more disturbing than romantic. In any event, the concept has moved beyond lyrical metaphor and into the form of a minuscule personal blood testing lab developed at the École Polytechnique Fédérale de Lausanne (EPFL, www.epfl.ch). The device — measuring only about 14 mm (0.55 in) long — actually contains five sensors, a coil for generating wireless power, and a transmitter allowing it to communicate via Bluetooth. Data is routed to a mobile phone, then to the doctor's cell phone. Outside the body, a battery patch generates 0.1W of power, so it never needs a battery replacement. The device is still in the prototype phase, but it has been demonstrated to detect up to five targeted proteins and organic acids simultaneously, including lactate, glucose, and adenosine triphosphate (ATP, used by cells to store energy).

Each sensor is coated with a specific enzyme that allows it to detect the substance of interest. "Potentially, we could detect just about anything," explained EPFL scientist Giovanni De Micheli. "But the enzymes have a limited lifespan, and we have to design them to last as long as possible."

Presently, that amounts to about 1.5 months, after which the implant is removed. Various applications are under consideration, but the device may be especially useful in chemotherapy to help monitor a patient's reaction to a particular dosage. Researchers hope the system will be commercially available within four years. ▲



■ The EPFL's prototype blood testing implant measures only about 14 mm.

Discuss this article in the Nuts & Volts forums at <http://forum.nutsvolts.com>.

COMPUTERS AND NETWORKING

BIG TABLET — REALLY BIG TABLET

If you're loving your iPad or other tablet but can't seem to get enough display area, check out the BigTouch® all-in-one touch screen PC from InFocus Corp (www.infocus.com). With its 55 inch 1080p display and a hefty 84 lb (38 kg) weight, you probably won't be using it for texting from your table at McDonald's, but it might come in handy for various business and educational purposes. You get a Windows 8 Professional OS and input via not only a wireless keyboard and mouse, but also a five-point touch screen that supports such gestures as slide, tap, swipe, pinch, and rotate.

It features two gigabit Ethernet ports, Wi-Fi, two HDMI ports, and six USB ports, as well as a 120 GB SSD. Processing power is provided by a less than state-of-the-art Intel i5 chip, but it does include vPro technology for embedded security, a customizable interface, and the Microsoft Office 2010 suite.

It also ships with Mondopad® software that allows such collaboration features as videoconferencing, digital document annotation, and interactive whiteboarding (i.e., placement of shared files on the same screen). Unlike other all-in-one units, you will be able to upgrade

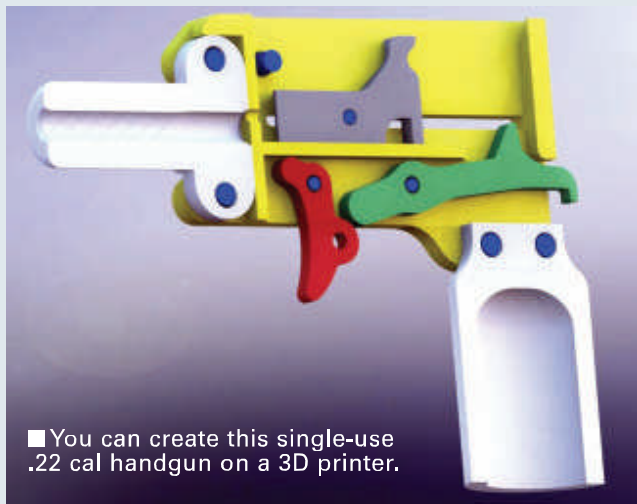


■ The BigTouch offers tablet-like operation on a 55 inch display.

the hardware and keep using the same display. The catch, of course, is the price. The MSRP is \$4,999. But hey, you have an expense account, don't you? ▲

WHO NEEDS SMITH & WESSON?

We'll go out on a short limb here and predict that the list of must-have computer peripherals will soon include a 3D printer as prices drop and clever folks everywhere keep coming up with nifty new applications and CAD files to use with them. One concept you have to stop and think about comes from an outfit called Defense Distributed (defensedistributed.com) — a pro-gun nonprofit organization. The org has a three-phase



■ You can create this single-use .22 cal handgun on a 3D printer.

plan: (1) Develop a fully printable firearm that will allow you to fire a single round without the thing blowing up; (2) Adapt the design to work on the cheapest 3D printers; and (3) Provide a "wiki" that allows participants to collaboratively produce, preserve, and distribute related knowledge.

You can already download a variety of designs from defcad.org — a site operated by DD. Many files are provided in STL (for stereolithography, a.k.a., Standard Tessellation Language), created by 3D Systems (www.3dsystems.com), and used by many software packages. Most of the available designs create parts for existing arms, such as a silencer or a lower receiver for an AR-15. The one depicted here is an entire .22 cal pistol, minus a spring that you can pick up at Lowe's or Home Depot. Before you get too excited, note that the creator warns that he has not actually printed and tested one, so if you want to keep your fingers, you probably shouldn't either. Plus, you will be in violation of at least two federal laws.

Clearly, this has far-reaching implications. As they say on the website, "This project might change the way we think about gun control and consumption. How do governments behave if they must one day operate on the assumption that any and every citizen has near instant access to a firearm through the Internet? Let's find out." ▲

COMPUTERS AND NETWORKING CONTINUED

SAVE GASOLINE, MAKE SOME \$\$

If you've been trying to come up with an idea for a money-making app, note that Ford Motor Company has issued a challenge to developers to write a mobile- or web-based one that will provide drivers with easy access to data about their fuel economy performance. Some details were unavailable as of this writing, but we know that the winner (or winners) will be awarded a share of the \$50,000 prize money. Developers must use data via the OpenXC platform, for which details and a tutorial can be found at openxcplatform.com. Ford began accepting submissions on April 24th, but you have until July 24th to send yours. Judging will end August 22nd, and winners will be announced on August 28th. To get started, just log onto ford.challengepost.com. ▲

CIRCUITS AND DEVICES

BAROMETER FOR TABLETS/SMARTPHONES

Your current smartphone or tablet circuitry probably doesn't include a barometer, but there's a pretty good chance that your next one will. The device has obvious uses in terms of weather apps and, in fact, Cumulonimbus (www.cumulonimbus.ca) has already introduced the pressureNET app, aimed at putting together a network of user-contributed pressure readings to improve weather forecasting over the globe. A barometer is also useful for detecting your altitude relative to sea level, thereby



■ Measurement Specialties' MS5637-02BA03 digital barometric pressure sensor module may be part of your next mobile device.

determining your location more accurately, so you don't have to be a meteorologist to make use of one.

To address this expanding market, Measurement Specialties, Inc. (www.meas-spec.com), has introduced its new MS5637-02BA03 digital barometric pressure sensor module — a MEMS-based ultra-compact (3 x 3 x 0.9 mm) one designed specifically for smartphones, tablets, and various personal navigation devices. It operates with a current consumption of only 0.6 μ A (standby <0.15 μ A) at 1.5V to 3.6V supply voltage and is rated at a pressure accuracy of ± 2 mBar at 25°C. It is suitable for pressures ranging from 300 to 1,200 mBar and temperatures from -20 to +85°C. The device communicates via an I²C interface and offers stability of ± 1 mBar per year.

Pricing is said to be less than \$1 per unit, but only if you can use a million of them. It's probably best to wait until manufacturers start using them rather than trying to install one yourself. ▲

TOP-SHELF AIRPLAY SPEAKER

If you want to stream music from your AirPlay-equipped device and don't mind shelling out some relatively big bucks to get a big sound, you might want to consider the Libratone Zipp offered by a small Danish audio company (www.libratone.com). The name comes from the zipper-equipped speaker covers which are fitted with real leather handles made from "fine Italian wool," and "handpicked to create the optimal sound experience combined with an exclusive look."

The Zipp uses the AirPlay spec to stream audio over your Wi-Fi network, and reviewers give it high marks in that mode. If you head for the park and don't have Wi-Fi access, you can still use it, as it offers the PlayDirect feature that turns the device into its own Wi-Fi hotspot. If you prefer, you can also use a wired connection via a USB or 3.5 mm mini jack.

The Zipp uses a four inch bass speaker and twin one inch ribbon tweeters to deliver 60W total, using the company's patented FullRoom DSP process in which the tweeters and midrange drivers disperse sound in different directions, reflecting it off the walls and providing 360°



■ Stream hi-fi music from your iPad, iPod, iPhone, or other device running iTunes 10.1 or above.

sound. The frequency range is 60 to 20,000 Hz with a maximum output of 96 dB SPL at 1 m. It's basically designed to be used with Apple products, but if you have iTunes 10.1 or above, you can use it from a PC.

One of the best features is that it provides up to eight hours of wired operation — or four hours wireless — on a battery charge, and it only takes 1.5 hours for a recharge. The main drawback for us cheapskates is that it will run you \$399 for the single color version, or \$449 with three replaceable covers in different colors. ▲

INDUSTRY AND THE PROFESSION

THE ALAN T. WATERMAN AWARD GOES TO ...

Princeton University's Mung Chiang, an electrical engineer who "uses innovative mathematical analyses to design simpler and more powerful wireless networks." The annual award is given by the National Science Foundation to outstanding researchers under the age of 35 in any NSF-supported field. Prof. Chiang's contributions have been applied to wireless net resource optimization, Internet congestion control, plus wireless signal traffic routing and resource distribution in cloud computing. According to Chiang, in his work, "We cut through the buzz words and get to the fundamentals."

We teach the key concepts in networking that help formulate and address central questions, those that teenagers can readily relate to in their daily lives."

The professor is no stranger to awards, having previously reeled in the IEEE's 2012 Kiyo Tomiyasu Award, US Presidential Early Career Award for Scientists and Engineers, the Office of Naval Research Young Investigator Award, and the MIT *Technology Review* young innovator award.

The Waterman award comes with a tidy \$1 million grant, to be spread out over five years. **NV**

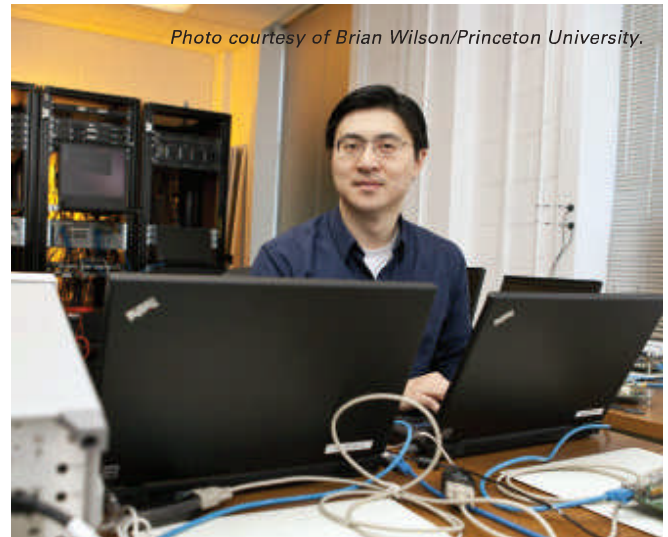


Photo courtesy of Brian Wilson/Princeton University.

■ Mung Chiang, winner of the 2013 Alan T. Waterman Award.

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GETTING STARTED WITH SURFACE-MOUNT SOLDERING

If you read the previous installment of the Primer, you're expecting that we'll finish our multiplexed LED project by constructing a strip board version of our previous breadboard circuit, so that we can insert the display into a breadboard directly alongside a 20M2 processor in any project that needs a two-digit display. Considering that, I can imagine that the title of this month's column must be a little confusing! We'll definitely finish our multiplexed LED project this month, but before we do that, I want to discuss some of the basics of hand-soldering surface-mounted devices (SMDs). I'm sure this topic seems unrelated to what we were doing last time, but before we're done, you will see why it's included in this installment.

INTRODUCTION TO SMDs

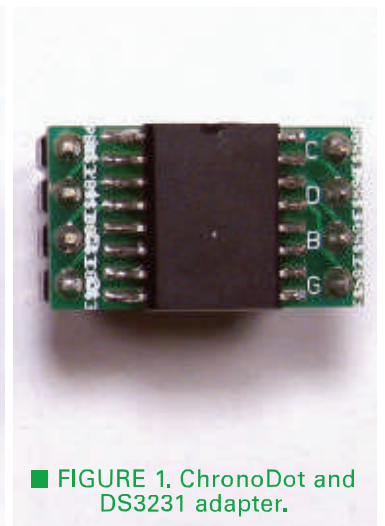
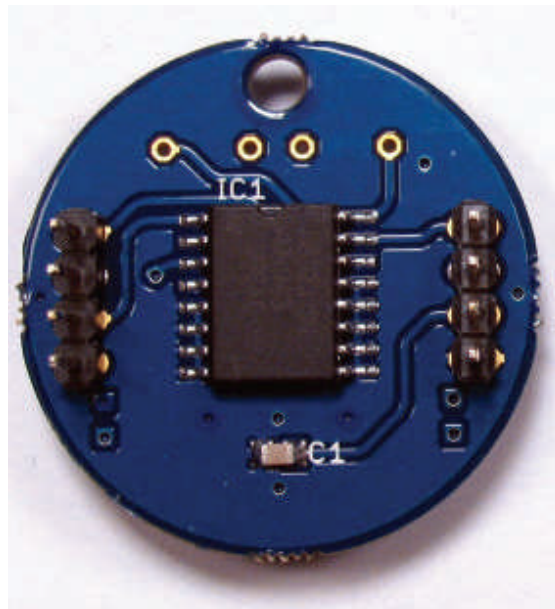
Recently, I've been running into a problem that you also may have experienced. I find a new component that piques my interest, and then discover that it's only available in an SMD package. Lately, that's been happening more and more frequently, which convinced me that — sooner or later — I would have to begin experimenting with hand-soldering SMDs.

When I discovered the DS3231, I knew I had to get over my fear! The DS3231 is a real time clock chip that's far more accurate than the DS107, and it includes an onboard quartz crystal, so an external one

isn't required in the circuit. The problem is that the DS3231 is only available in a Small Outline IC (SOIC, a.k.a., SO) package.

In case you're also interested in the DS3231 but aren't yet ready to try your hand at SMD soldering, **Adafruit.com** offers a small printed circuit board (PCB) called the ChronoDot that has the DS3231 already soldered in place.

The ChronoDot can be directly inserted into a breadboard, so it's really easy to use. **Figure 1** is a photo of the bottom of the ChronoDot next to my hand-soldered board for comparison. (Just ignore the illegible writing near the left edge of my board — I had a minor problem with that prototype.)



■ **FIGURE 1.** ChronoDot and DS3231 adapter.

It may seem odd that both boards in the photo only have two four-pin headers for insertion into a breadboard, but for some reason eight of the DS3231's 16 pins do not connect to anything.

After you have finished this article and practiced a little SMD soldering on your own, you may also want to try your hand at soldering SOIC devices. If so, there are literally hundreds of SOIC to DIP adapters available on eBay. Also, I intend to discuss the DS3231 in detail in a future installment of the Primer, and I'll add a custom PCB to my site for use with that particular article.

If you're familiar with SOIC chips, you know that the pin spacing is 0.05 inches, which is exactly half that of the DIP chips we're used to using. Of course, there are many sizes of SMDs with pins spaced much more closely than 0.05", but soldering those devices generally requires special techniques and/or fairly expensive equipment. We won't be discussing those devices, but there's a wealth of information online; just search for "surface-mount soldering tutorial."

If you do some online searching, you will quickly learn that many people use fairly expensive equipment, including hot air rework stations and even surface-mount reflow soldering ovens that can cost hundreds of dollars. However, if we limit ourselves to SOIC devices and the larger sizes of passive devices (resistors, capacitors, LEDs, etc.), we really don't need to spend much at all to get started with SMDs. The equipment listed here is all that's required.

Figure 3 shows the size comparisons of the SMDs that we'll be discussing in this article. The decimal rule in the photo is graduated in tenths of an inch (with 0.02" subdivisions). In order



■ **FIGURE 2.** Tweezers for SMD soldering.

- **A soldering iron with a long, thin tip.** I use a Weller WESD-51 temperature-controlled soldering station with an ETS long conical tip, but any soldering iron will work; it's the long thin tip that's important.

- **A spool of very thin solder.** RadioShack sells a small spool of 0.015 inch diameter solder (catalog #64-035) that's perfect for soldering SMDs by hand. Larger spools of the same diameter solder are also available online.

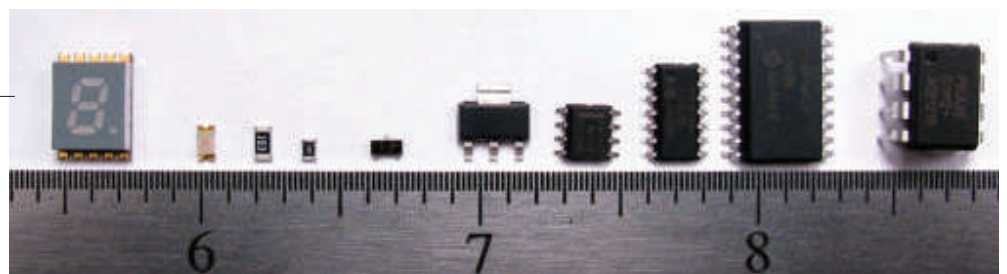
- **Desoldering braid.** In the event of an accidental solder bridge between two pins, it's helpful to have a roll of desoldering braid (solder wick) to remove that bridge. Again, RadioShack sells a small spool (catalog #64-2090), and solder wick is also readily available online.

- **Tweezers.** Most SMDs are too small to manipulate by hand or even with needle-nose pliers, so tweezers are a necessity. To get started, I would

suggest a pair of regular straight tweezers and a pair of locking straight tweezers. (Locking tweezers must be squeezed to open their points, so they are useful as temporary clamps to hold a component in place as it's being soldered.)

It's also helpful to have a regular bent tweezer and a locking bent tweezer in some situations. As with the soldering iron, it's important that the points are long and thin (sometimes referred to as "precision" tweezers). Fortunately, there are many inexpensive tweezers available on eBay and elsewhere for sale (refer to **Figure 2**).

- **Good magnification and lighting.** As with through hole soldering, good magnification and lighting is important. You don't really need a binocular microscope for the SMD sizes we will be discussing, but a good magnifying visor or a magnifying desk lamp is essential.



■ **FIGURE 3.** SMD size comparisons.

to provide a visual reference for the sizes of the SMDs, I included a standard PICAXE-08M2 in a DIP package on the extreme right.

On the extreme left is a surface-mount single digit seven-segment LED display, which I only included as one example of the variety of SMDs that are currently available.

Let's take a brief look at each of the remaining devices, from left to right:

• **LED in a 1206 SMD package.**

Resistors, capacitors, diodes, and many other passive components are available in several different SMD sizes — each of which is identified by a four-digit number. The first two digits specify the length and the last two digits specify the width in units of 0.01". This red LED is in a 1206 package, i.e., it's 0.12" long and 0.06" wide.

• **Resistor (10K).** This resistor is also in a 1206 package, so it's the same physical size as the LED. In the photo, I hope you can see the "103" label that identifies it as a 10K resistor (10 x 10 to the 3rd power). A 220Ω resistor would be labeled "221" (22 x 10 to the 1st power).

• **Resistor (10K).** This is another 10K resistor; this time in an 0805

package. Passive devices are also available in much smaller sizes, but 0805 is the smallest package that I can easily solder by hand. After I have had more practice, I may try the 0603 size if I'm feeling brave.

• **Example of an SOT-23 package.** This SMD size is commonly used for small signal transistors (including the 2N3904 and 2N3906) and several logic devices. I have to confess that I don't know what this particular SOT-23 contains. It's labeled "1P," but I haven't been able to find a match among the other SMDs I've been using to practice soldering. This highlights an important point. If you intend to do much work with SMDs, you need to develop a more organized storage system than I have at present!

• **Voltage regulator, 5V (LD1117) in an SOT-223 package.**

As you can see in the photo, the SOT-223 package is much larger than the SOT-23 package. As a result, it's also much easier to solder. In fact, it's the easiest of all the packages shown in Figure 3, and probably the best place to begin if you want to try your hand at SMD soldering. SOT-223 devices are frequently used for voltage

regulators, power transistors, and small signal transistors, among other devices. (The 2N3904 and 2N3906 are available in both SOT-23 and SOT-223 packages.)

• **CD40107 in an SOIC-8 package.** This is a dual two-input NAND buffer. SMD logic gates are a good choice for practicing soldering because they are relatively inexpensive. Many other ICs (including PICAXE processors) are available in various SOIC sizes.

• **PICAXE-14M in an SOIC-14 package.** This is just another SOIC package; this time with 14 pins.

• **PICAXE-20X2 in an SOIC-20 package.** This package is referred to as a wide SOIC because its body is wider than the standard SOIC body. The DS3231 that we saw back in Figure 1 is also a wide SOIC.

There are many other sizes of SMD packages. Some are larger and many are smaller — small enough to make them just about impossible to solder by hand.

For example, resistors and capacitors are commonly available in a 0201 size (0.02" by 0.01"). Understandably, we're going to avoid these guys!

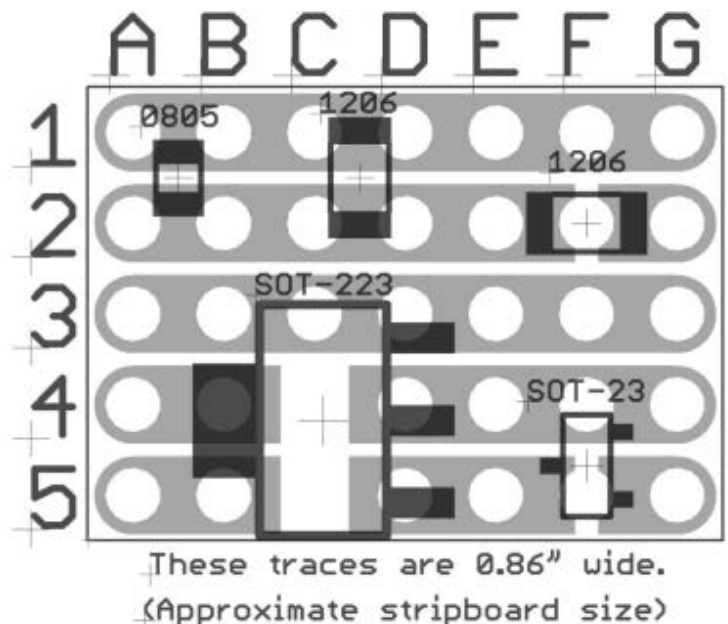
EASING INTO SMD SOLDERING

Now that we have a basic understanding of the SMD sizes that we're discussing, let's focus on how to begin to actually solder these devices. Naturally, my preference was to begin with strip boards because I have a large supply of small, leftover pieces that I can sacrifice to the early stages of practice.

Figure 4 shows the strip board placements that I've found to be the easiest to use for soldering the following four SMD packages: 0805, 1206, SOT-223, and SOT-23.

Before we discuss each of the devices, I need to explain the unusual

■ **FIGURE 4.** SMD layout for practice.



appearance of this diagram. As you know, I typically use LochMaster to present strip board layouts. However, it turned out to be tedious to get LochMaster to position components slightly off-center from the strip board traces (which is sometimes necessary to do for an SMD), so I decided to use the EAGLE PCB layout software for **Figure 4**.

The colors (or lack thereof) may seem a little strange, but I think the final diagram accurately presents the necessary positioning for each of the SMDs. It's important to remember that we're not discussing any kind of a functional circuit here — just five independent devices soldered to the same strip board for practice.

With that caveat in mind, let's discuss each of the five SMDs, starting at the upper left corner of the strip board. For the 0805 and the 1206 devices shown in rows 1 and 2, the black rectangular regions on each device do not represent a pin or tab; those rectangles indicate the areas on the main body of each device that have been pre-tinned, so that the device can be soldered at each end by positioning the tip of a soldering iron so that it contacts the edge of the device and the strip board trace at the same time.

When that junction is heated sufficiently, a small amount of solder will wick around and under the end of the device, securely attaching it to the strip board trace on which

the device is placed.

As you can see, an 0805 device and a 1206 device can each easily be positioned so that they straddle two adjacent traces without needing to cut either trace. Since the 0805 device doesn't really save much space, 1206 devices are all we ever need to use on a strip board.

Another advantage of using 1206 devices on strip boards is that they can also be positioned on a single trace by cutting the trace at a hole. However, the necessary cut at hole F2 is a little unusual in that we can't just use a drill bit or strip board tool to do the job because it would remove too much copper, which could create problems for soldering the 1206 in place.

Instead, we need to use a small chisel or sharp utility knife to make the two thin cuts shown in **Figure 4** (one at the top of hole F2 and one at the bottom). That way, a minimum of copper is removed, and both ends of the device are fully positioned on the trace.

Even though we don't really need to use 0805 devices in a strip board circuit, it's still a good idea to practice soldering them on a strip board. The reason is that they do save a fair amount of space on a PCB, so practicing on a strip board will help you feel more confident when approaching the same task on a printed circuit board. In contrast to the 0805 and 1206 devices, the

black rectangular regions on each of the two SOT devices in **Figure 4** do represent pins or tabs that protrude from the body of the device. If you look closely at the SOT-223, you will see that it's placed slightly off-center from the mid-line of trace 4.

Centering the SOT-223 on trace 4 would result in the large tab on its left edge touching traces 2, 3, and 4, which would necessitate cutting trace 3 at the C3 hole. Of course, this isn't a big deal, but the slight offset avoids the extra work. In many (but not all) SOT-223 devices, the large tab is also connected to one of the pins on the other side of the device. If the tab happens to be connected to the middle pin, trace 4 wouldn't need to be cut at position C4.

Whenever an SOT-223 device is used, be sure to check its datasheet to determine which pin (if any) connects to the large tab.

The SOT-23 device in the lower right corner of **Figure 4** may be the most difficult to solder, due to the relatively small size of its pins. These devices must also be offset a little, so that two of the three pins are fully positioned on one trace, and that trace must be severed at the hole that separates the two pins on the trace; in this case, that's hole F5.

Just use this same approach for the hole at F2. Again, a minimum of copper is removed, and the two small pins that are on trace 5 are both fully positioned on the copper.

HOLDING SMDs IN POSITION WHILE SOLDERING

Now that we know how to position the devices on the strip board, the next question is "How do we hold them in place while soldering?"

For the purely hand-soldered approach that we're discussing, my online searching turned up two fairly common approaches. However,

every link that I found limited their discussions to PCBs, and the methods used didn't seem to be very appropriate for strip board soldering. So, I did some experimenting to see how the task can be accomplished on a strip board.

Before we get into the details of my approach, I just want to mention two other approaches because you may find them helpful when you need to solder SMDs on PCBs.

The first — and most common — approach is to use your soldering

iron to tin one of the device's pads on the PCB by melting a small amount of solder onto the pad. Then, with your soldering iron in one hand and the device held by a pair of tweezers in the other, you re-heat the solder on the pad, slide the device into its proper position with one pin in the melted solder, and allow the solder to cool. The process is a little difficult to explain clearly in words, so here's a link to a very informative video tutorial: <http://tan-gentsoft.net/elec/movies/tt03.html>.

The reason I found this approach to be a little difficult to use on strip boards is that on a PCB, the SMD pads are very small, and each pad has a solder mask surrounding its edges. As a result, the melted solder is easily contained within the outline of the pad, even when the solder is re-melted to slide the SMD into position. On a strip board, however, the melted solder tends to flow outwards onto a relatively long section of a trace, and it spreads even further when it is re-melted.

The second less common approach is to use a very small piece of “Fun-Tak,” or any other brand of soft putty that’s often used to stick posters on a wall. To do this, you simply place a tiny piece of putty on the bottom of the device and then stick it to the PCB.

Actually, this approach could probably work on a strip board, but it’s usually only used on SOIC and other SMD ICs. (Can you imagine trying to place a piece of putty on the bottom of an 0805 resistor?)

Unfortunately, the 0.05” pin

spacing of SOIC ICs precludes them from being soldered onto a strip board, anyway. However, whenever you do need to solder an SOIC device on a PCB, you may find poster tack to be helpful. So, here’s a “how-to” video of that technique as well: <http://blog.makezine.com/projects/circuit-skills-surface-mount-devices>.

The technique that I’ve been using to solder SMDs is relatively simple, and it works well for me on both strip boards and printed circuit boards, so let’s take a look at that approach. I think the easiest way to explain it is via a concrete example, so we’ll use the **Figure 4** strip board layout that we just discussed, and actually solder the five SMD components in place. (Suitable SMD components are available at www.JRHackett.net and elsewhere.)

If you refer back to **Figure 4**, you can see that we’re looking at the bottom of the strip board. (That’s the only view we need, because we’re not installing anything on the top of the board.) Of course, the first step is

to make the four necessary cuts in the traces as shown in **Figure 4**.

When we make the two cuts at holes C4 and C5, we can use our usual approach (i.e., cut the traces with a drill bit or strip board tool). However, due to the small size of the 1206 and SOT-23 devices, we need to use a small chisel to cut the traces at holes F2 and F5 (as described earlier).

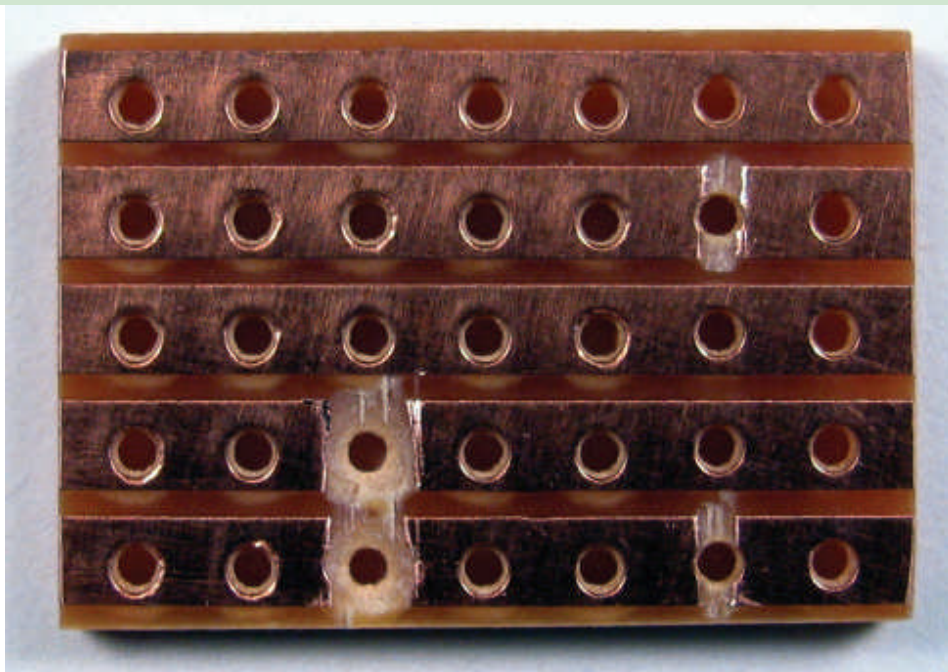
Figure 5 is a photo of my board after I made the required cuts. As you can see, the amount of copper removed at holes F2 and F5 is much less than what was removed from holes C4 and C5.

As you know, it’s generally a good idea to solder components onto a strip board or PCB in height order (lowest to highest) to avoid having the larger components get in the way of soldering the smaller ones. However, our little practice project is so small that it really doesn’t matter. If fact, I would suggest that you reverse that order for your first few practice boards because it’s generally easier to solder larger SMDs in place than it is to solder the smaller ones.

So, let’s begin with the SOT-223, and then work our way down to the more challenging smaller components. The following list of instructions is how I solder most SMDs to a strip board. At first, you may want to follow it closely in order to see how it works for you, but I would also encourage you to experiment until you find the most workable procedure for yourself.

A little warning: This list is a bit wordy, but I think the extra detail is helpful the first time around.

1. Place the following items within easy reach of your work surface: heated soldering iron with a thin point; spool of 0.015” solder; “helping hand” with one of



■ **FIGURE 5.** Strip board ready to solder.

its jaws in a horizontal position about one inch above your work surface; a small block of wood about the size of a small breadboard; two pairs of tweezers (one straight locking and one non-locking, either bent or straight); a straight dental pick or something small and reasonably pointed (even a toothpick is fine); the prepared strip board; and the SMD to be soldered.

2. Pick up the strip board, hold it horizontally in your non-dominant hand, and use the pair of non-locking tweezers (in your dominant hand) to pick up and position the SMD on top of the board as accurately as you can. Don't worry about perfection at this point; we'll adjust the final position shortly.

3. Set down the non-locking tweezers and pick up the locking tweezers. Press them open, and then use them to "pinch" the SMD against the strip board. Refer to **Figure 6**.

4. Set down the non-locking tweezers and insert the back end of the locking tweezers — which are still "pinching" the strip board and SMD together — into the jaw of the helping hand.

5. Place the small block of wood under the strip board, and then lower the tweezer so that the strip board is resting on the wood. Check out the photo in **Figure 7** (which I forgot to take until I was finished with the entire board!).

6. Starting with the easiest pin to reach, position your hot soldering iron so that the tip is touching both the end of the pin and the trace.

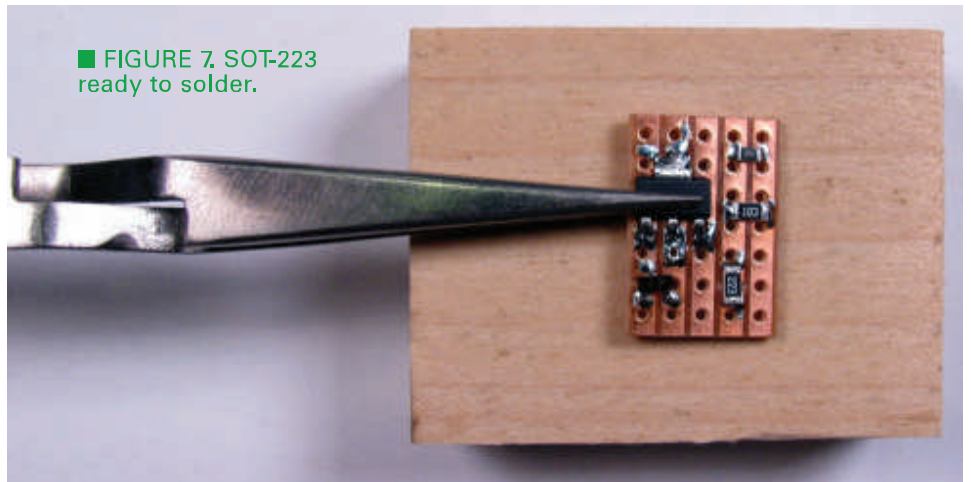
7. When the junction is hot enough — using the smallest amount of solder you can — solder the pin to the trace.

8. Solder the remaining pins in the same manner. **Figure 8** is a photo of my strip board after the SOT-223 was soldered in place. As you can see, I used too much solder on the tab and on the middle pin on the right. However, the circuit would still be perfectly functional.

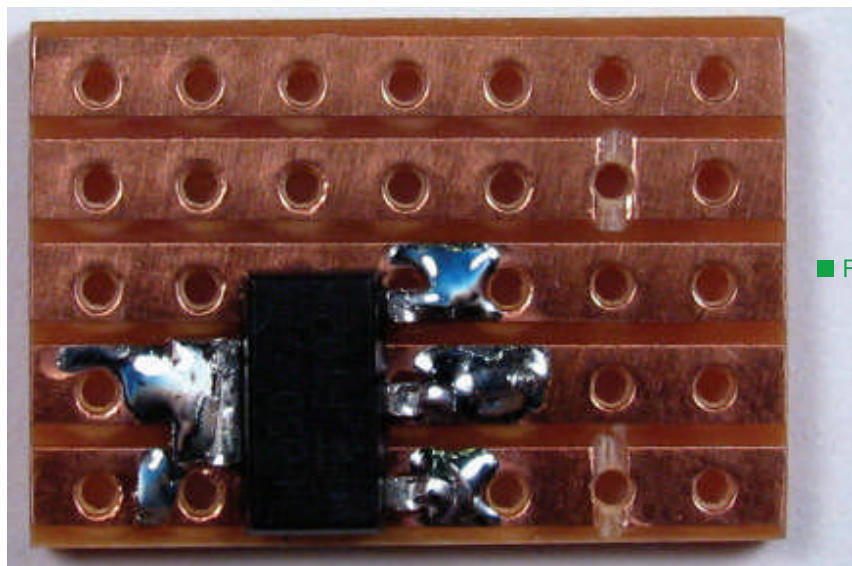
■ FIGURE 6. SOT-223 held in place.

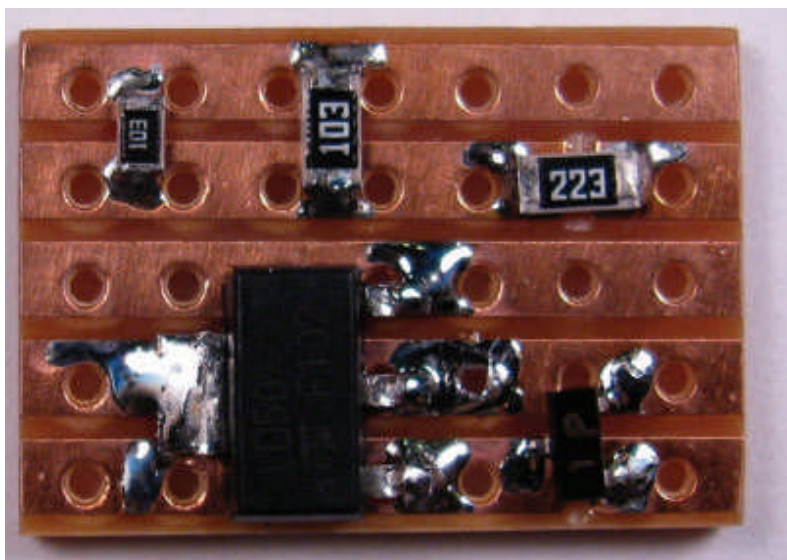


■ FIGURE 7. SOT-223 ready to solder.



■ FIGURE 8. SOT-223 soldered.





■ FIGURE 9. Strip board completed.

If you needed to access the hole to the right of the middle pin (the one I covered with solder), you could use a piece of solder wick to remove the excess solder.

9. Following the above steps, solder the remaining SMDs in place. **Figure 9** is a photo of my completed board, on which I did remove the excess solder that was covering hole E4. Also, you can clearly see that I didn't perfectly position the rightmost 1206 22K resistor, but again, the circuit would work fine.

When you have completed your board, you may want to test it for accidental shorts between the various pins. You can also check for the correct resistances. Don't forget that there are two parallel resistors between trace 1 and 2, so on my board, I measured a 5K resistance between those two traces.

So, that's it! With a little practice, you will probably be surprised at how easy it is to solder SMDs that are in the size range we just discussed. Also, as I mentioned earlier, it's even easier to do on a PCB — especially those that include a SOIC device or two. This opens up a whole new world of possibilities for our PICAXE projects.

I already have several ideas for new projects that will involve SMDs

in their design, including the DS3231 project that I mentioned earlier.

FINISHING UP OUR MULTIPLEXED LED PROJECT

Completing our multiplexed LED project is simple; all we need to do is construct a strip board that contains the circuitry that we used in the previous installment of the Primer.

Figure 10 shows a strip board layout that will do the job. (A larger-sized version of the layout is available

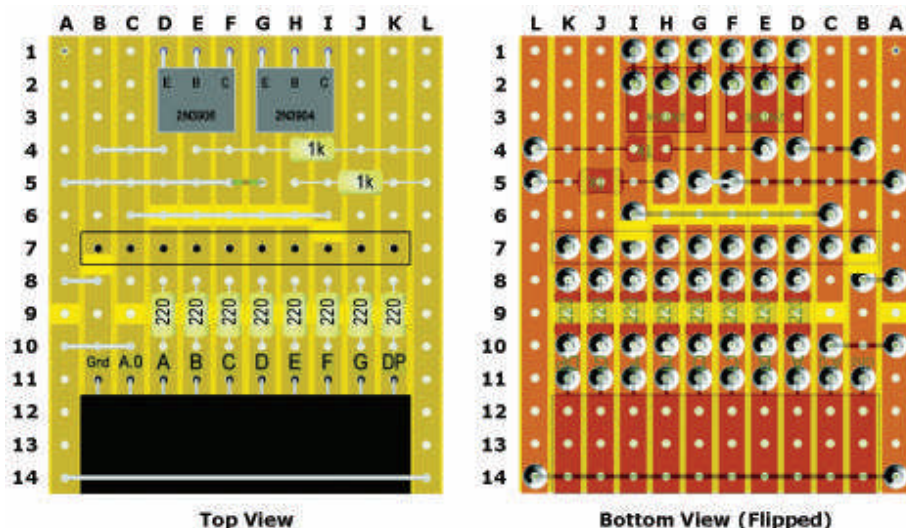
at the article link.) The strip board is very easy to construct, but there are a couple of points that I need to clarify.

First, the N514RI display must be the **last** component to be installed. Also, the pins of the two transistors need to be bent so that when they are inserted into the strip board, the flat surface of each transistor is flush against the top surface of the strip board. That way, when the N514RI is finally installed (with its pins inserted as shown in row 7), the display can lie almost flat against the strip board, completely covering rows 1 through 7 as shown in the completed project in **Figure 11**.

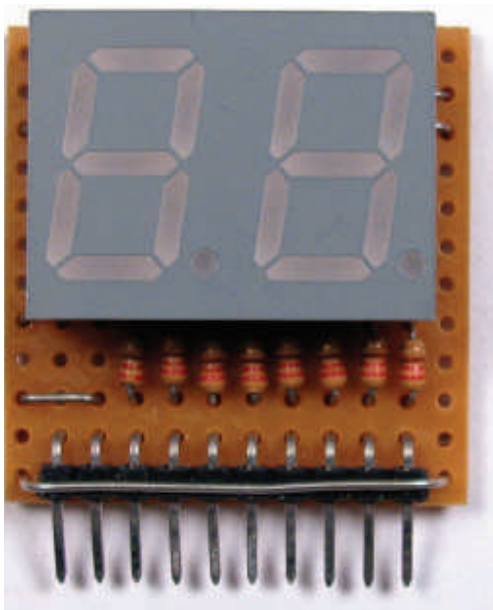
In that **figure**, you can see that I used a male header (rather than the female header shown in the layout of **Figure 10**). I knew I was going to construct two of these boards, and I wanted to have one with a male header and the other with a female header.

If you decide to use a male header, note that you can completely remove rows 13 and 14 of the layout. However, the long jumper from A14 to L14 must be moved up to row 12 as shown in **Figure 11**. (That jumper completes the connection from A.0 to the two 1K resistors.)

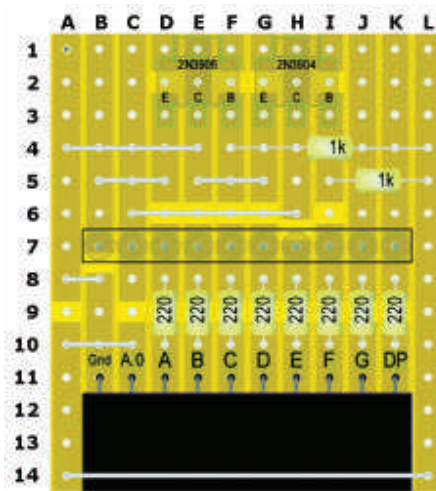
As I just mentioned, the LED display ended up almost flat against the strip board. Actually, the two



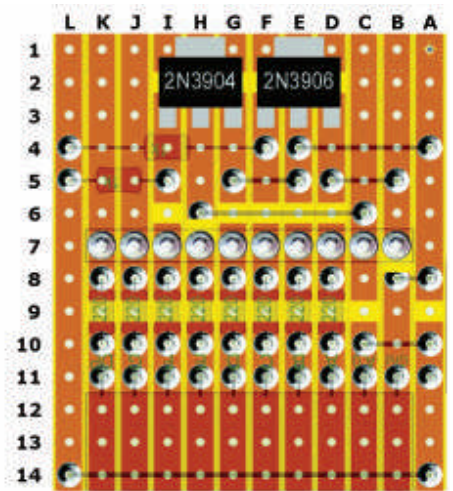
■ FIGURE 10. Strip board layout for multiplexed LED.



■ FIGURE 11. Top view of finished board.

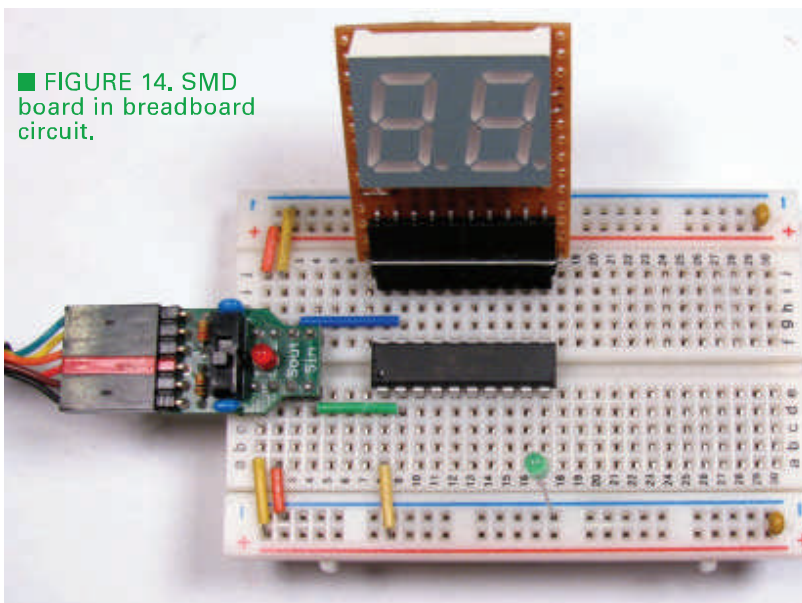


Top View



Bottom View (Flipped)

■ FIGURE 12. Stripboard layout for SMD version.



■ FIGURE 14. SMD board in breadboard circuit.



■ FIGURE 13. Bottom view of finished SMD board.

transistors raised the display about 0.1" above the surface of the strip board. When I decided to make a second display, I wanted to see if I could eliminate that small gap, which is how SMDs became involved in this project.

I redesigned the strip board layout and placed SOT-223 versions of both transistors on the bottom of the board; the resulting layout is shown in **Figure 12** (again, a larger-sized version is available at the [article link](#)).

Unfortunately, the pins of the

SMD transistors are in a different order than those of the through hole versions, so I also had to make a couple of minor modifications to the strip board wiring. If you compare the two layouts (**Figures 10** and **12**), you'll see what I mean.

Figure 13 is a photo of the two SMDs soldered to the bottom of the strip board. You can tell that I soldered them in place after sanding the bottom of the board and, again, I used a little too much solder (filling

two holes in the process). The board was already fully populated, however, so it doesn't matter.

Figure 14 shows the completed board inserted into a breadboard, directly in line with a 20M2 processor. After I completed both versions of the board, I used the *Count2Digits3Tasks.bas* program (from the April 2013 Primer) to test them. Guess what — both boards did

not function correctly! The tens and ones columns were displayed in reversed order.

What had happened was obvious — I had accidentally reversed the connections to the two transistors. In the original version of the circuit, pin 1 of the N514RI was connected to the 2N3904; pin 2 was connected to the 2N3906. Somehow I managed to reverse those two connections!

Since I had already soldered both displays in place, modifying the strip board circuits would not be an easy task. Fortunately, the error was easy to correct in software; I just reversed things there, as well.

The new program (*Count2Digits3TasksV2.bas*) works fine, and it's also available for downloading at the article link. You may want to compare it to the original version of the program to see

how the reversal is implemented. Of course, you also have the option of correcting my little mistake in the two layouts before you build either board, or you can just use the updated software to accomplish the same thing.

A PARTING QUESTION

As usual, we're out of space, but I have a question to ask. By now, you've probably heard about the Raspberry Pi phenomenon. (If not, just Google it — you'll get more than 50 million hits!) In a nutshell, the Raspberry Pi is a complete single board, Linux-based computer that connects to a monitor or TV and a keyboard. The RPi (as it's frequently called) has 512 MB of onboard memory and it includes 17 digital I/O lines, as well as connectors for an SD card, two USB ports, audio

output, and Ethernet, so it's Internet-ready.

In addition, a USB Wi-Fi dongle can be added for connecting to your wireless LAN — an amazing set of capabilities for a \$35 credit card-sized computer!

For the past few weeks, I've been experimenting with interfacing PICAXE processors with the RPi, and I'm really impressed with the possibilities. In the coming months, I plan to continue my exploration of this powerful combination, which brings me to my question: Would you like a piece of PICAXE® Pi?

Let me know (Ron@JRHackett.net) if you would like to see some PICAXE-Pi coverage in the Primer. If there seems to be enough interest, I would be more than happy to include it. In the meantime, practice your SMD soldering, experiment, and have fun ... **NV**



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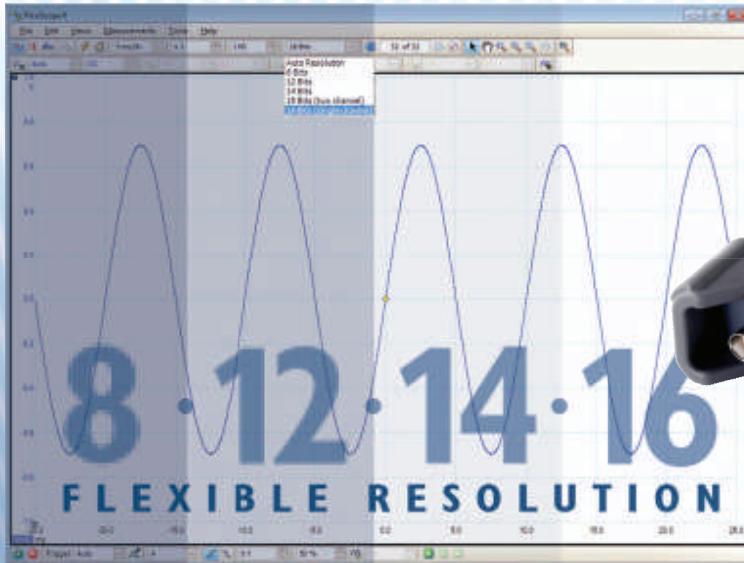
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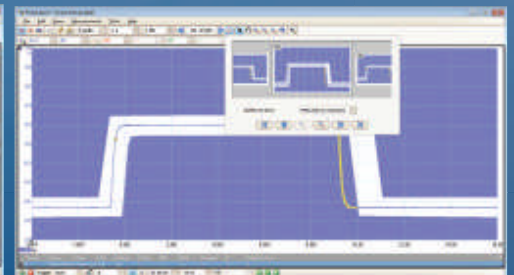
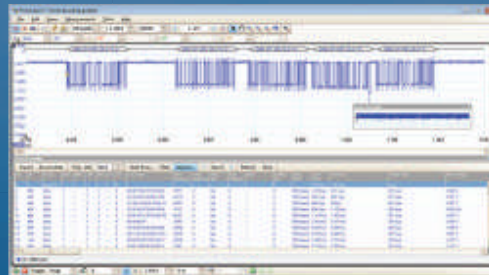
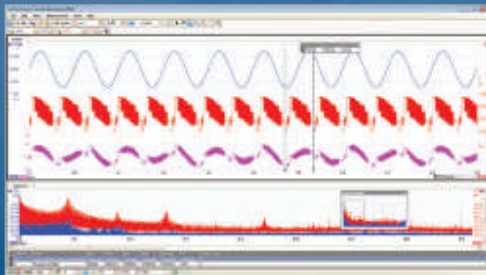


PicoScope	PicoScope 5442A	PicoScope 5442B	PicoScope 5443A	PicoScope 5443B	PicoScope 5444A	PicoScope 5444B
Channels	4					
Bandwidth	All modes: 60 MHz		8 to 15-bit modes: 100 MHz 16-bit mode: 60 MHz		8 to 15-bit modes: 200 MHz 16-bit mode: 60 MHz	
Max. sampling rate	8-bit mode		12-bit mode	14-bit mode	15-bit mode	16-bit mode
Any 1 channel	1 GS/s		500 MS/s	125 MS/s	125 MS/s	62.5 MS/s
Any 2 channels	500 MS/s		250 MS/s	125 MS/s	125 MS/s	-
Any 3 channels	250 MS/s		125 MS/s	125 MS/s	-	-
Four channels	250 MS/s		125 MS/s	125 MS/s	-	-
Sampling rate - ETS (8-bit mode only)	2.5 GS/s		5 GS/s		10 GS/s	
Buffer memory (8-bit) *	16 MS	32 MS	64 MS	128 MS	256 MS	512 MS
Buffer memory (≥ 12 -bit)*	8 MS	16 MS	32 MS	64 MS	128 MS	256 MS
Resolution (enhanced)**	8 bits, 12 bits, 14 bits, 15 bits, 16 bits (hardware resolution + 4 bits)					
Signal Generator	Function generator	AWG	Function generator	AWG	Function generator	AWG

2 Channel models also available. * Shared between active channels

** Maximum resolution is limited on the lowest voltage ranges: ± 10 mV = 8 bits • ± 20 mV = 12 bits. All other ranges can use full resolution.

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QUESTIONS & ANSWERS

■ WITH
RUSSELL KINCAID

In this column, Russ answers questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions. Send all questions and comments to: Q&A@nutsvolts.com

IR SENSOR

Q I have a small vineyard; it's a 400 ft run of various grapes for eating and wine. Birds are a big problem ...

they think they know when the grapes are ripe. The grapes look good and smell good, but the birds will peck at each one trying to find that sweet one. I've tried cyclic and distress type scares, but to no avail. Neighbors don't like the birds, either.

I would like to try some ideas on having an air poppet type noise sound off when a varmint enters the immediate area. I don't know how much of an IR footprint a bird has, but motion sensors pick up on leaf movement too.

I would like to build a bunch of small units, pot them against the environment, and have them able to drive a 24 VDC air solenoid (air and DC voltage available along arbor). I'm thinking one every 10 feet, or closer to get the right IR ID. The solenoid could be a triggered one-shot, or maybe in some ramp-up/ramp-down fashion. Any ideas?

— Rich Harrison

A Harbor Freight Tools sells an IR sensor that turns on a light at night when motion is sensed. I had one; I removed the light and replaced it with a solid-state relay. The daylight sensor was covered with tape so it worked all the time. A person could stand in the view of the sensor and not be detected, but any movement would set it off. I don't know how

close a bird would have to be to get sensed, but it's worth a shot.

This sensor does not use the Doppler effect; I think it senses distortion of the IR field, so I wonder if an object (like leaves) that is not warmer than the surroundings would be sensed.

BATTERY QUESTION

Q I am a long-time reader of your column and I'm hoping you can give me some advice. I'm working on a battery-powered project. The components have an absolute max voltage of 5.5V and a minimum operating threshold of around 3.6V. In standby mode, the current drain is around 200 μ A and in active mode, around 500 mA. Three C or D alkaline cells would do the job, but I'm trying to hold down operational costs by using rechargeable batteries.

I would like to use NiMH cells because of their good low temperature operation and low self-discharge. Four cells would give me a good range of operation, except that when fully charged they would exceed the max voltage allowed. Is there some way to limit the full charge voltage to a safe level without hurting capacity too much?

I could use more cells and regulate the voltage down to 5V or so, but the regulator would have to be very efficient to minimize standby current drain and still provide at least 500 mA in active mode. I'm stumped and I'd appreciate any suggestions.

— Richard Duncan

A It seems to me that a switching power supply is what you need. I searched the Mouser catalog and found one for \$9.52. The load is not isolated from the battery, but you don't need that. It is rated 15 watts, so your application at 2.5 watts will be no sweat. Efficiency is said to be 90% (probably at full load and max input voltage).

The input voltage range is 3V to 13.8 VDC, and the output is adjustable from .59V to 5.1V. The supply draws 50 mA no load, but it has an enable pin that will allow you to shut it down where it draws 5 mA.

If your circuit is mostly in standby, you may want to use a solid-state relay to disconnect the battery during standby. The datasheet doesn't say, but the output adjustment is probably a trimpot. The Mouser part number is 826-LDO03C-005W05-VJ.

ELECTRIC FENCE INDICATOR

Q I'm looking to build a simple detector circuit to test my electric fence. It can be a tone or a lamp, but preferably an LED circuit that I can hang on the fence permanently. Thanks.

— Mike Phillips

A A neon lamp should work; the electric fence produces high voltage — just what the neon lamp requires. You will need some series resistance,

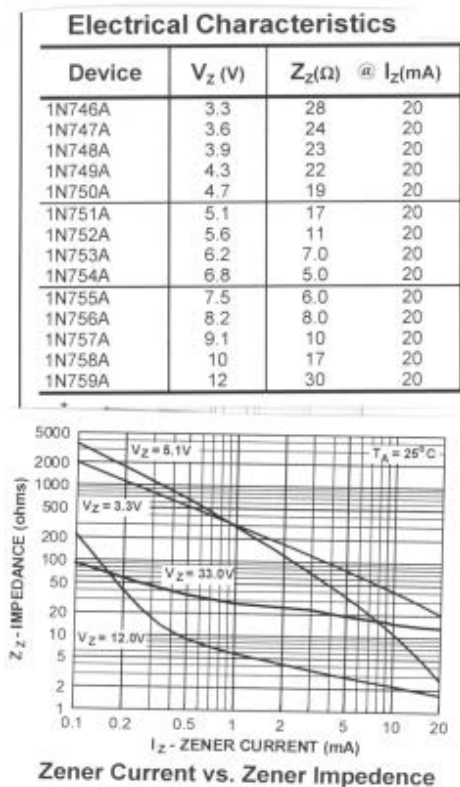
otherwise, the neon will soak up the power and it won't be shocking. I think one megohm high voltage resistor in series will work; otherwise, use 10 100K resistors.

The circuit is connected between the fence wire and earth ground. A suitable lamp is Mouser 607-1050A2; it mounts in a 1/2 inch hole and has flexible wire leads. This one is clear but red, green, amber, and white are available.

DATASHEET ERROR?

Q We are using the zener in **Figure 1** in one of our labs and the datasheet looks wrong. Does that happen often? We are using the 5.1V, and the datasheet gives the test current through the zener at 20 mA along with the impedance. If you look at the graphs for zener current and zener impedance, none of the values match up for 20 mA. The graphs have to be wrong, right?

— Matthew Kincaid



■ FIGURE 1.

A No. It's the difference between worst case and typical case. The manufacturer shoots for three ohms at 20 mA for the 1N751, but will still ship zeners that measure 17 ohms. In a production environment, you should always design for the worst case. For large quantities, a manufacturer will modify the specs to whatever you need.

DIAL LAMP MODIFICATION

Q I own a Realistic shortwave radio DX-440 and use it during the night time. The radio has a dial lamp that comes on momentarily at the push of the button. I'd like to modify it so — using the same switch — the light remains on for a longer period, and goes off when pushed for a second time. Can you help me find a circuit to do it?

— Patricio Giron

A I looked up your radio and it does not appear as if it would be easy to change the switch, even though mechanical switches that do the job are available. You will need to disconnect the wires from the switch and connect the switch to the circuit shown in **Figure 2**.

The disconnected wires go to the solid-state relay. The lamp can go on either side of the relay; it is only

necessary that the current go from POS to NEG. The relay — as configured — is rated 750 mA, 100V max. You can run the circuit on the lamp voltage if it is under 15 volts DC. Otherwise, you will have to find another source.

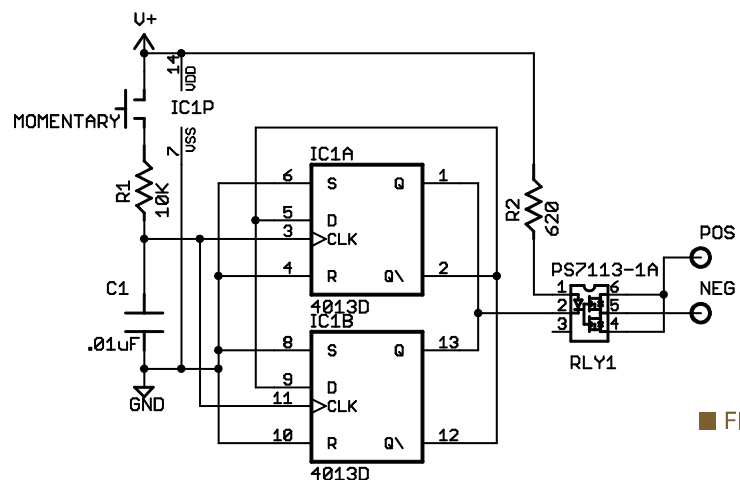
The circuit uses a D type flip-flop. Each time it is clocked, it changes state; one click on, one click off. The two flip-flops are paralleled to provide more drive to the relay. The relay part number is Mouser 551-PS7113-1A-A, \$3.65; the flip-flop is dip14, Mouser 595-CD4013BEE4, \$0.41

Jameco has similar parts. For the relay: 1583041, \$4.95, 60V, one amp, dip6. For the dual flip-flop: 12677, \$0.39, dip14.

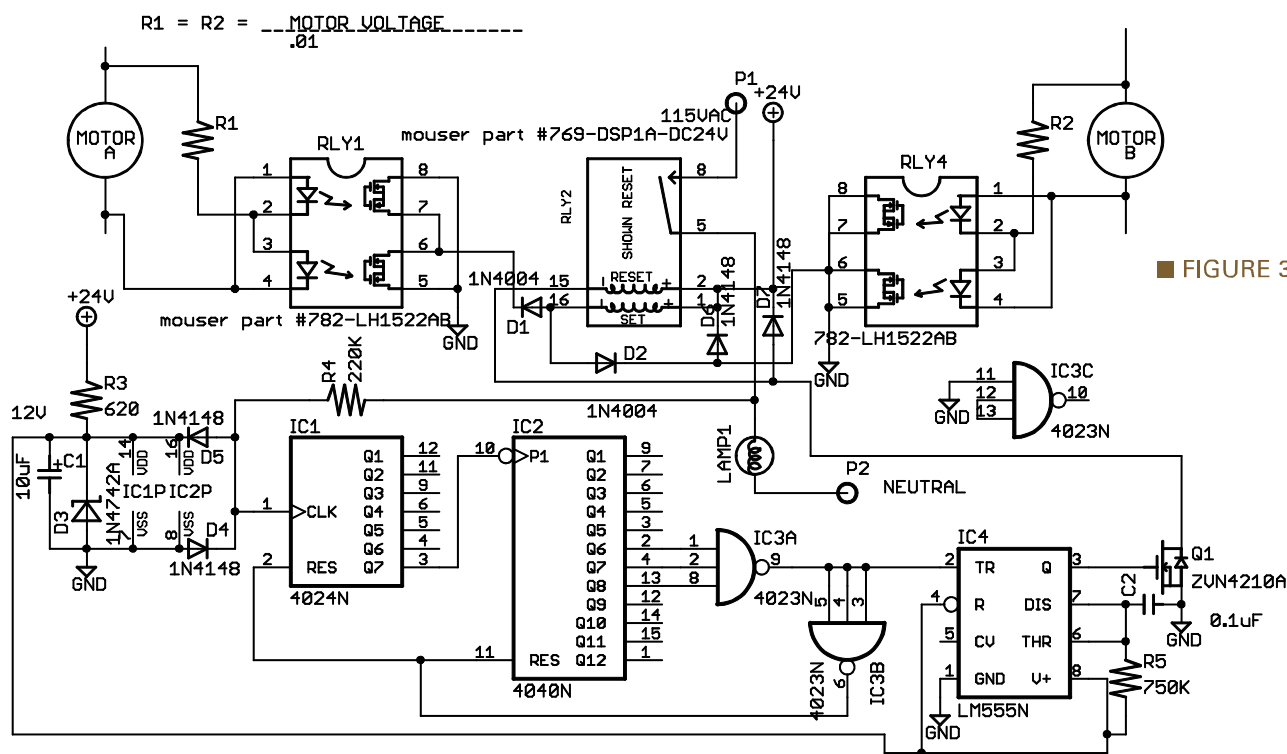
GARAGE DOOR LIGHT

Q I have two garage doors with commercial operators. I would like to have both operate one light; and have both the open and close time be 15 min. They are each controlled with 24 volt separate circuits and radio control.

— Keith Menard



■ FIGURE 2.



■ FIGURE 3.

A Look at the circuit in **Figure 3**. You will have to select a relay coil voltage that is compatible with the motor voltage; I don't know what that is. The relay is magnetically latched with set and reset coils. The timer — clocked by 60 Hz and operating from the 24 volt DC control voltage — will release the latch in 15 minutes.

Since I don't know whether the motor is operated on 24 VDC or 115 VAC, the solid-state relays, RLY1 and RLY2, are configured to operate on either. The one shot, IC4, produces a pulse just long enough to reset the latching relay.

INTERCOM SYSTEM

Q When I was a kid, my parents had a Fanon intercom set. My mom used it to wake up my brother and me every morning so we could get to school on time. It was a wired system which had the master station in the kitchen and two slave stations (one in my room, the other

in my brother's room). I believe it was wired with a two conductor cable. These slave stations were simply cabinets with speakers.

When my mom wanted to talk to us, she pushed the “talk button.” When she released the button, she could hear what my brother and I said. In fact, she could eavesdrop on us at any time without us knowing (like a modern baby monitor). My brother and I could not hear each other's comments. In those days, the system used a tube amp. I would love to have a similar system in my house, but all I see are wireless systems, cheap battery operated systems, or very expensive fancy systems.

How hard would it be to build a modern solid-state equivalent of the old fashioned Fanon system that I grew up with? Such a system would more than meet my needs.

— Guy Fischetti

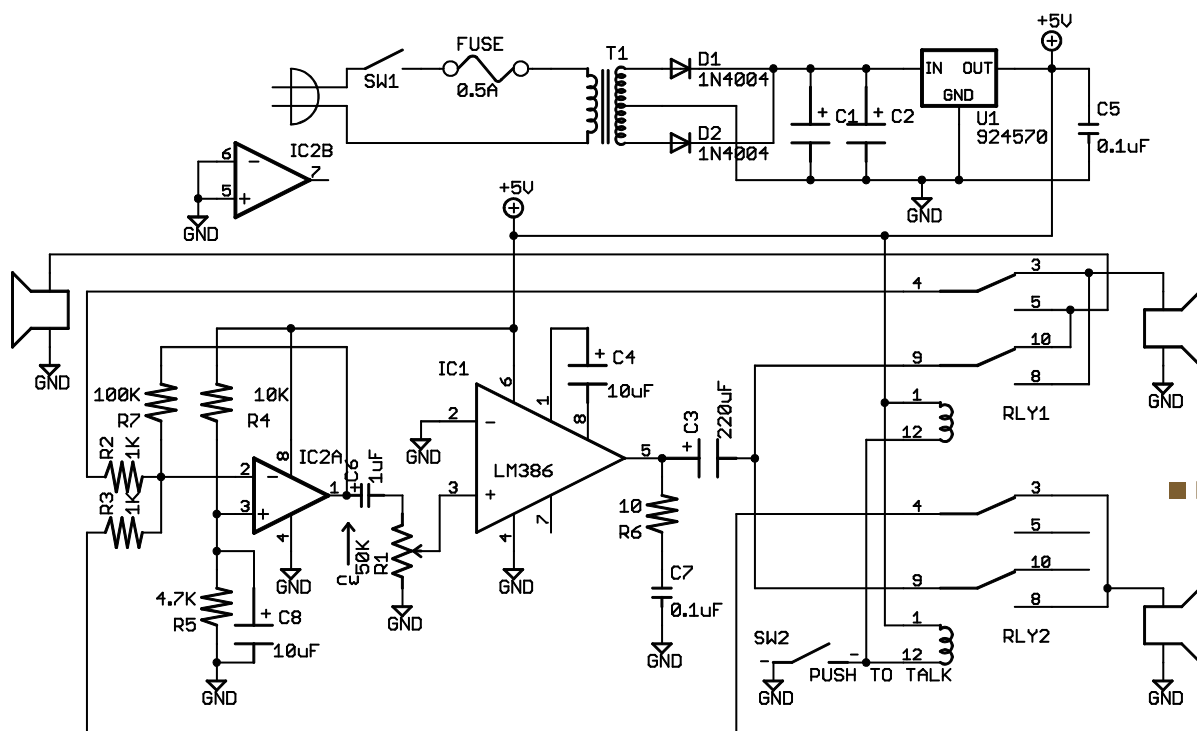
A If you look at **Figure 4**, you'll see I have replicated the Fanon intercom. When the press-to-talk switch

(SW2) is pressed, the master speaker is connected to the amplifier input as a microphone and the amp output is connected to the two remote speakers.

You may want to use two LM386 audio amps: one for each remote speaker because the speakers are four ohms; two in parallel are two ohms. The output impedance of the amplifier — about two ohms — will cause a drop in available output voltage. Using two amplifiers will allow more voltage and increased power ($P = E^2/R$).

If you do use two LM386s, you may want to also have two volume controls so you can turn down the channel you don't want to listen to. The preamp (IC2) has a gain of 100 and the LM386 has a gain of 200, so the overall gain is 2,000 — which should be enough, even though the speaker as a microphone puts out a small signal.

R6 and C7 are required for stability of the LM386, according to the datasheet. **Figure 5** is the Parts List.



■ FIGURE 4.

INTERCOM PARTS LIST

PART	DESCRIPTION	JAMECO #
SW1	SPST POWER SWITCH	317287
FUSE	5x20 MM CLIP	1712608
T1	115V/12VCT TWO AMPS	29226
D1, D2	1N4004 DIODE, 400V, 1A	35991
C1, C2	3,300 μ F, 16V	198898
U1	VOLTAGE REG 5V, 1.5A	924570
C5, C7	0.1 μ F, 50V, +80-20% Z5U	15272
SPEAKERS	4 OHM, 4" DIA	2099614
C3	220 μ F, 16V	30496
SW2	PUSHBUTTON, MOMENTARY	315660
RLY1, RLY2	RELAY, DPDT, 5V COIL	2135291
R1	50K POT, PANEL MOUNT	255434
IC1	LM386N AUDIO AMP	24125
IC2	LM358AN DUAL OP-AMP	120862
C4, C8	10 μ F, 16V, RADIAL	198839
C6	1 μ F, 50V, RADIAL	29831
R2, R3	1K, 5%, 1/8W	
R4	10K, 5%, 1/8W	
R5	4.7K, 5%, 1/8W	
R6	10 OHMS, 5%, 1/8W	
R7	100K, 5%, 1/8W	

■ FIGURE 5.

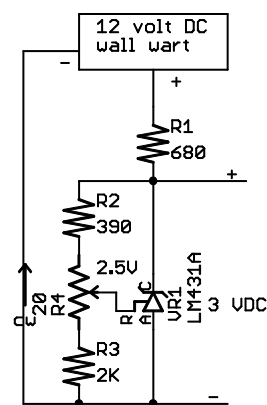
(purchased from **goldmine-elec.com**; #G14801) which would power-up several kits, each being rated at 3 VDC @ 10 mA — i.e., one is this five LED random/sequence flasher whose prerequisite for operating current is 10-16 mA because of the CMOS VLSI single chip-on-board contained in the circuit (any higher current would destroy the chip-on-board).

— Michael Williams

A Since efficiency is not a consideration, a shunt regulator is the simplest solution. Take a look at **Figure 6**. The LM431A is rated at 36 volts and 100 mA max, and the reference voltage is 2.5V $\pm 2\%$. The theoretical value for R2 is 400 ohms, so the 20 ohm pot allows you to get the right value and also trim out the tolerance. The load current is limited to 15 mA by R1; if the load tries to draw more current, the voltage will reduce.

HIGH VOLTAGE GENERATOR

Q My project is a simple one. I only want to make sparks! Either a mesmerizing toy to watch or a Jacob's ladder. I have this circuit I built to drive



■ FIGURE 6.

DC-TO-DC REGULATOR

Q I would like to build a well regulated step-down DC-to-DC power regulator built with minimal parts (from Mouser), with an input of 12 VDC @ 200 mA and an output of 3 VDC @ 10 mA. Can you please help create such a schematic? I have several 12 VDC wall adapters rated at 200 mA

a small single sparkplug ignition coil. The primary winding is 1.9 ohms and

the secondary is 7.24K. The circuit is powered with a 12 volt, five amp power supply.

Basically, I used an NTE4584B hex inverter; the first two inverter logic gates along with D1, D2, C2, VR1, and VR2 produce a square wave with an adjustable duty cycle and frequency.

The remaining gates are used to amplify the signal. Q1 (2N3904NPN) and Q2 (MJ2955 PNP) are set up as a Sziklai pair to supply the negative side of the ignition coil to ground. I tried to block any EMF with C4 (R3 as a snubber), and D3 and D4.

On a USB oscilloscope, I get a square wave between the outputs of the hex inverter (pins 6, 8, 10, 12) and ground. The signal is approximately 25% to 75% duty cycle, and frequency adjustment is between 5.5 kHz and 16 kHz. I'm

getting an inverted signal at Q2.

Measurements of 10 kHz 50% duty cycle at Q1 between collector and ground are:

9.8V Max Voltage
-70 mV Min Voltage
9.9V Peak-Peak
4.93V Mean Voltage
6.89V RMS

At Q2 between emitter and ground:

9.8V Max Voltage
-390 mV Min Voltage
10.19V Peak-Peak
4.62 Mean Voltage
6.89V RMS

Should I be getting the min voltage closer to 0? When I connected the coil, the spark I got was very small and barely visible.

What frequency would do the

MAILBAG

Re: Remote Tester Problem, March 2013, page 21.

Any cell phone and most digital cameras will detect the emission from IR remote controls. Since most of us have cell phone cameras (try to buy one without!) or some type of digital camera, these work well for verifying the output of an IR remote control. My 14 year old grandson clued me in on this.

Paul Haug

I tried it with my cell phone camera and it works; thanks for the info.

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best? What can I do to achieve a longer, bigger spark?

— Mike Wandishin

A I reproduced your circuit in **Figure 7**. The main problem I see is D4, which limits the flyback voltage.

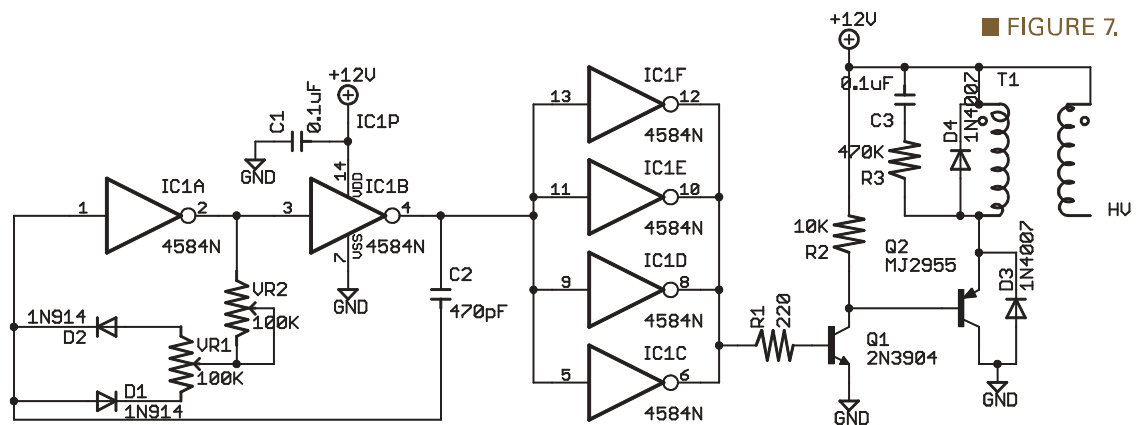
The primary voltage needs to be free to go as high as necessary to allow the secondary to generate the spark. The snubber, R3 and C4, is a futile effort because the Jacob's ladder is radiating and annoying the neighbors, anyway. The transistors should be rated 200 or 300 volts; if

they blow up, go higher. R2 should be connected to the Q2 emitter – not to 12 volts – to protect the base-emitter junction of Q2. The higher the frequency, the better; as long as it does not exceed the self-resonant frequency of the coil.

The way to find the resonant frequency is to drive the secondary

through 100K and monitor the primary for a peak frequency.

Your oscillator circuit is unique; I have not seen that before. I have seen the Q1-Q2 transistor arrangement often, but never knew that it had a name. Thanks for your question. **NV**



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Suitable for use in industries such as automotive, solar, and electronics manufacturing, this high performance DC electronic load system is designed for characterizing a wide range of DC power sources, including multi-output AC/DC power supplies, batteries, fuel cells, and photovoltaic arrays.

All DC load modules in the MDL Series can operate in constant current (CC), constant voltage (CV), constant resistance (CR), constant power (CW), and constant impedance (CZ) mode, which uses DSP technology to simulate realistic

non-linear loading behavior.

Depending on the module, users can select from operating voltage and current ranges up to 500V and 120A. A 250W dual-channel module supporting flexible power allocation up to 300W is also offered. Load modules in the MDL Series mainframe can be synchronized and connected in parallel for increased current and power.

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BUILDING AN ELECTRIC GUITAR

By Craig A. Lindley

I built an acoustic guitar a few years back, which turned out to be a lot of work (see craigandheather.net/cgitpage.html if you are interested in seeing that process). I wasn't aware I wanted to build an *electric* guitar until I got an email from the Stewart-MacDonald company describing what is probably the easiest electric guitar one can construct. This guitar was simpler than most electric guitars for two main reasons:

1. It utilized a pre-built electric guitar neck with frets already installed and already finished. Using a pre-built neck cuts days — or weeks — out of the guitar making process.
2. The body was a simple rectangle instead of the more complex shaped bodies found on many electric guitars.

As soon as I saw this, I knew I had to build one. I remembered that Bo Diddley played a rectangular guitar, so I knew I would be in good company. The Gretsch music company even made rectangular guitars for a while. The instrument I had in mind would have the neck and the playability of a Fender Telecaster/Stratocaster electric guitar, with the pickups and hardware of a Gibson Les Paul. A crossover guitar, so to speak.

If you are not familiar with Telecaster (Tele), Stratocaster (Strat), or Les Paul guitars, look them up at wikipedia.org. Wikipedia is also a great resource for checking out any guitar terms used in this article that you may be unfamiliar with.

Convinced I should build one, I immediately started thinking about all of the individual pieces/parts that make up an electric guitar: the neck, tuning heads, neck screws, neck plate, pickups, switches, controls, etc. As you can imagine, the list gets long very quickly. I toyed with the idea of buying a used electric guitar and scavenging the parts from that, but I couldn't bring myself to dismantle a perfectly good instrument.

In the end, I decided to buy all of the parts individually even though that would cost a little more. I stumbled upon a site called **GuitarFetish.com** which offered most of the parts I would need at reasonable prices. I made up a rather long list of components (see **Table 1**) and placed the order (total of \$280 in December

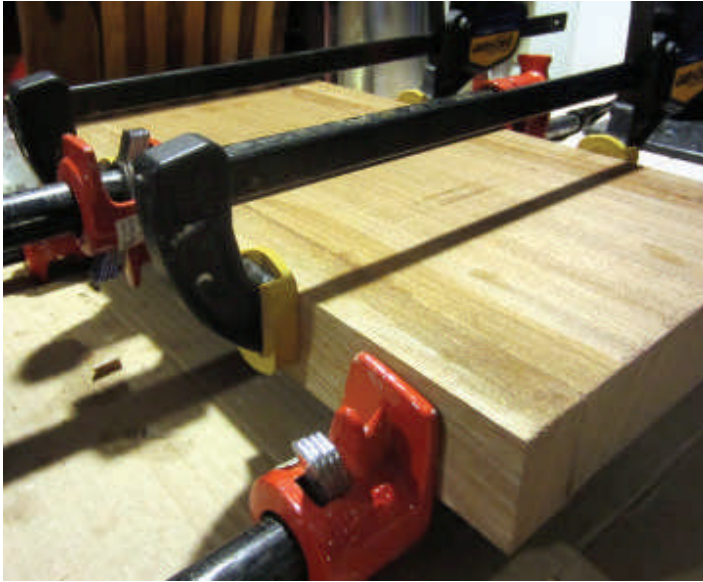
2012). With that done, I started to think about how to build the body of the guitar.

Electric guitar bodies are usually made with some kind of hardwood. Guitar building forums have endless debates about which woods are best. Many insist the more dense the wood is, the better sustain the guitar will have. Originally, I wanted to make the guitar body out of black walnut but I couldn't find a board locally that was thick enough and not seriously warped.

Instead, I purchased a beautiful, perfectly straight two inch thick piece of Sapele (*Entandrophragma cylindricum*) wood from Woodcraft. Sapele is a tropical African hardwood (also known as sapelli or aboudikro) used by many guitar manufacturers because of its tonal properties. The Sapele board I bought was not wide enough for my guitar body, so I had to glue 1-1/2" pieces to each side of it since the finished size of the guitar blank (body) needed to be 9 1/2" x 17". **Photo 1** shows the clamps holding the glued pieces together.



After the glue dried, I ran the blank through my planer to remove the glue residue and to flatten the top and bottom (see **Photo 2**).



■ **PHOTO 1.** Gluing up the Sapele guitar body.



■ **PHOTO 2.** After the glue dried, but before planing.

GUITAR HARDWARE PARTS LIST

■ **TABLE I.**

QTY	ITEM	PART #	DESCRIPTION
1	Pre-made neck	TLCGMP	Clear gloss finished Telecaster neck with maple fingerboard
1	Gold neck plate	K02	Gold neck plate with screws
1	Tuneomatic bridge	B06	Large bushing Tuneomatic style gold bridge
1 set	Tuners	E17	Gold Gotoh style 14:1 tuners
1	Control plate	K05	Telecaster gold vintage style control plate
1 pair	Strap buttons	K32	Gold strap buttons with screws
1 pair	String trees	K35	Gold string trees. (Only used one of the two.)
1	Tailpiece	GTS09GD	Gold tailpiece with mounting studs
1	Neck pickup	H182	Gold neck mini humbucker pickup
1	Bridge pickup	H183	Gold bridge mini humbucker pickup
1	Pickup selector switch	F24F167	Three-way Telecaster style pickup selector switch with screws and black top hat tip; switch is 2P3T.
1 pair	Knobs	A03	Gold knurled brass Telecaster knobs for split shaft pots
2	Potentiometers	F22	Full size 250K audio taper potentiometers (pots)
1	Capacitor	F36	.047 µf Sprague orange drop capacitor
1	1/4" output jack	F17	1/4" mono output jack
1	Output jack mount	4283-G	Gold Electrosocket jack mount purchased from stewmac.com .

NOTE: All components were purchased from **guitarfetish.com** except as noted.

RESOURCES

COMPANY	WEBSITE	DESCRIPTION
Warmoth	www.warmoth.com	Electric guitar and electric bass bodies, necks, and assorted hardware made in the USA.
Guitar Fetish	www.guitarfetish.com	Suppliers of all things guitar from parts to complete guitars.
Stewart-MacDonald	www.stewmac.com	Supplier of guitar parts, luthier tools to make guitars, and acoustic and electric guitar kits, plus much more.
Allparts Music Corporation	www.allparts.com	Supplier of electric guitar parts and accessories.
Greasy Groove, Inc.	www.greasygroove.com	Supplier of electric guitar parts and stylish accessories.



■ **PHOTO 3.** Gluing the ash inlaid strip around the body.

Next step was to machine a dado (slot) around the blank's perimeter using dado blades on my table saw. This was necessary because I wanted to inlay white ash around the body for an artistic touch. The light colored ash contrasts nicely with the dark Sapele. I did the same thing with the ash trim for a coffee table I built. (It always gets comments from the people who see it.) Of course, this is an optional step you don't have to do if you build a guitar like this.

I mitered the ash corners to 45 degrees and fit the ash into the dado. In **Photo 3**, I'm gluing the ash onto the Sapele body. After the glue dried, I trimmed up the body edges on the table saw so the ash was flush with the Sapele.

You might be asking yourself at this point if I had plans I was working from to build this guitar. The answer would be no. I did, however, know the most important piece of information about the guitar I was building and that was its scale length (which is a function of the Fender style neck I chose to use).

Scale length is the distance from the nut of the guitar (above the first fret) to its bridge. In my case, that was 25.5".

It is absolutely critical that the distance from the nut to the 12th fret be exactly equal to the distance from the 12th fret to the bridge of the guitar. If not, the guitar will have bad intonation which — in severe cases — can make the guitar unplayable.

Luckily, the bridge I selected was adjustable which made getting the scale length correct much easier.

The guitar dimensions evolved as follows. First, I laid out and machined the neck cavity so I could insert the neck into the body. Next, I measured 12.75" from the 12th fret and drew a line for where the bridge would be located. I placed the tailpiece 1.5" behind the bridge line and the bridge pickup position 1.5" in front of the bridge. Finally, the neck pickup was positioned as close as possible to the end of the neck.

Placement of the control cavity, strap buttons, and output jack are not critical, so I placed them where I thought they looked and would work best.

I built custom templates for my router for the neck cavity and for the pickup cavities (pre-made templates can be purchased from stewmac.com). I used a flush cutting router bit with the bearing on the shaft towards the router.

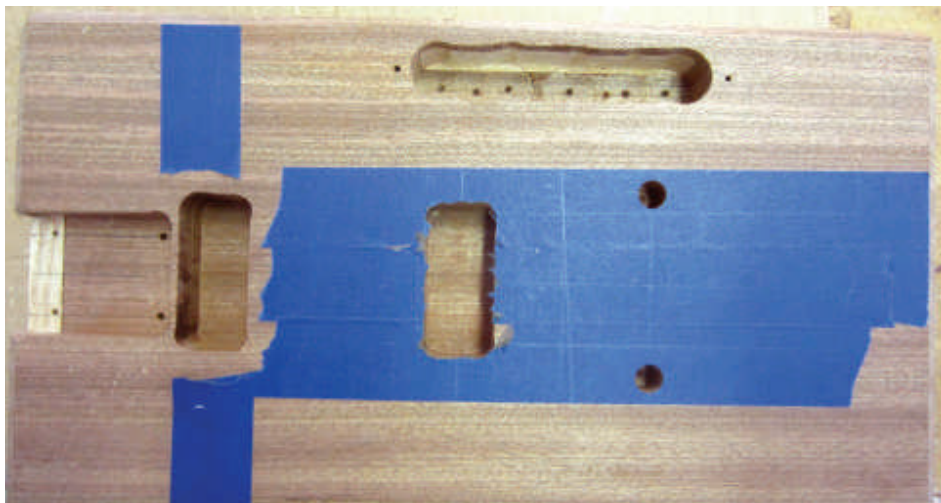
The bearing rides on the template to make correctly shaped cavities. This was kind of a pain because you cannot cut the full depth of the cavities in a single pass. So, I had to elevate the template on spacers, make a cutting pass, lower the template a little, make another pass, then remove the spacers under the template and make a final pass.

I machined cavities for the neck, both pickups, and for the guitar's control panel. My guitar will have simple controls like a Fender Telecaster guitar: a three-position pickup selector switch, and a volume and tone control.

Craig lives in the mountains of Colorado and can be contacted at calhjh@gmail.com. When not messing around with music, electronics, computer projects, wood working or beer brewing, he plays in a rock and roll band and does a solo musical act around Colorado Springs.

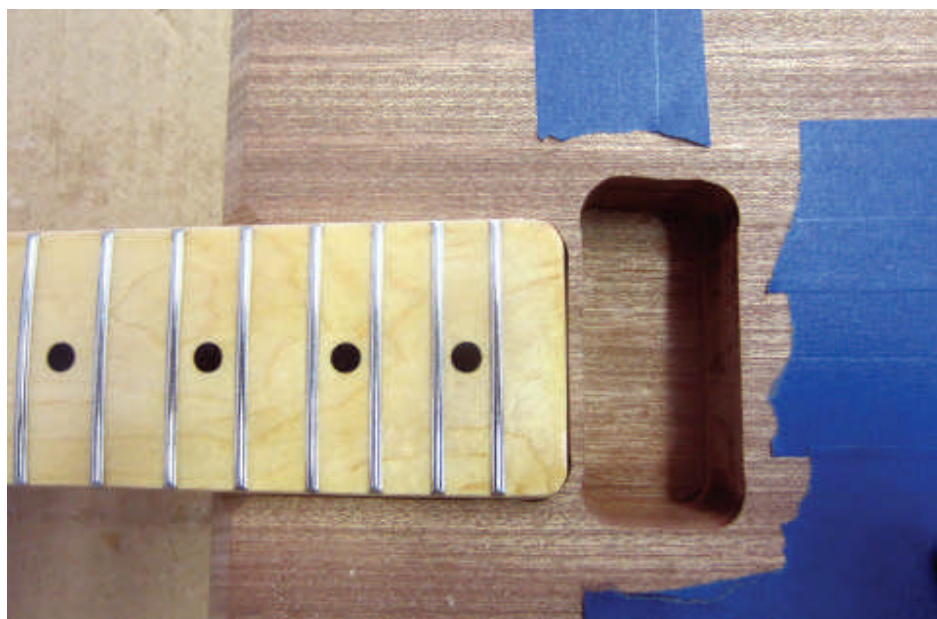
■ **PHOTO 4.** Machining of the body almost complete.

If you look closely at **Photo 4**, you can see pencil lines on the tape. The vertical line at a small angle from vertical is for placement of the bridge. The bass side of the bridge must be offset an additional 1/8" for proper intonation. **Photo 5** shows how the neck fits tightly into the body.



In **Photo 6**, you can see I drilled out the holes for the tuning keys and mounted them. I also drilled the four holes in the body for the neck plate. This type of guitar is referred to as a "bolt on neck" guitar as opposed to a guitar where the neck is glued permanently to the body.

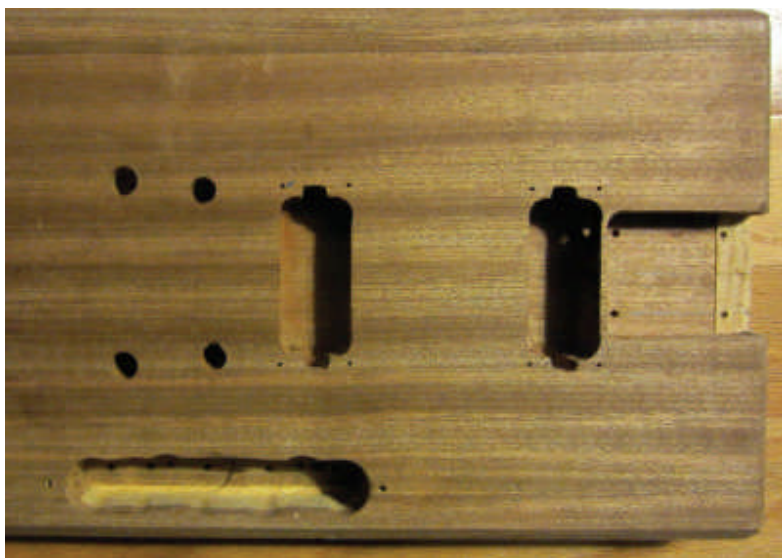
The four gold neck screws will pass through a gold metal neck plate, then through the body of the guitar and into the wood of the neck. You can also see in the photo that I beveled all of the hard edges on the body at a 45 degree angle. This makes the guitar more comfortable to play.



■ **PHOTO 5.** Closeup of the neck in the neck cavity and adjacent neck pickup cavity.



■ **PHOTO 6.** Fitting the neck to the body, and the drilled and mounted tuning keys.



■ **PHOTO 7.** Body after the application of Tung Oil finish.

The final machining steps shown in **Photo 7** were to drill holes for the bridge supports, the mounting holes for the pickups, and for the control panel. What you cannot see in this photo is that I had to drill holes/tunnels between the pickups and the control cavity, and between the bridge support hole and the control cavity, so I could run the electrical wires that I will eventually hook up to make the guitar function.

I also drilled a 7/8" hole in the bottom of the guitar for the output jack. I had to drill a tunnel for this connection, as well. Finally, I applied five coats of Tung Oil finish to bring out the nice Sapele wood grain. The neck (as mentioned) was already finished.

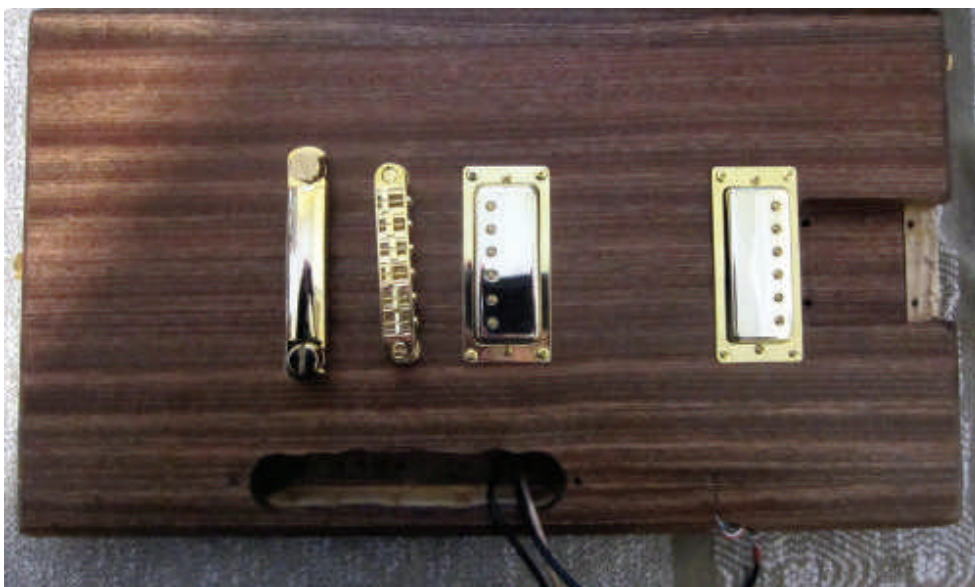
Photo 8 show the back of the body after finishing.



■ **PHOTO 8.** Rear of body after finishing. Note neck screw holes.

With machining and finishing completed, I mounted the major components into the body and pulled the wires into the control cavity making sure I placed the neck pickup next to the neck and the bridge pickup next to the bridge because they are different. Refer to **Photo 9**.

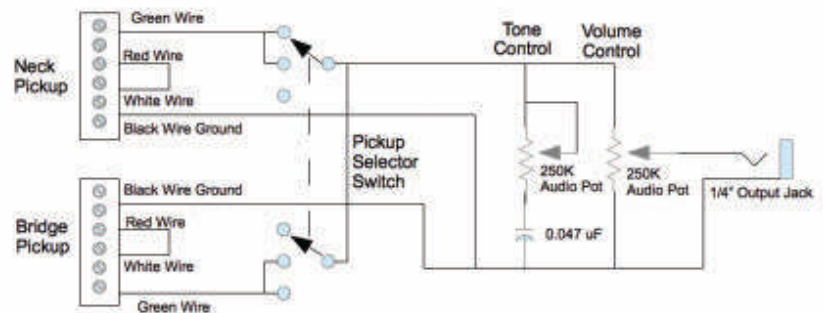
■ **PHOTO 9.** Installation of the tailpiece, bridge, and pickups.



The electronic portion of the guitar is really very simple (see the schematic in **Figure 1**). It consists of a three-position selector 2P3T switch which selects the neck pickup (for a more bassy sound) in the forward position, the bridge pickup (for more treble) in the rear position, and both pickups together in the middle position.

The middle volume control governs the overall volume of the guitar, and the tone control rolls off the highs (via a first order R-C low pass filter) as it is rotated counter-clockwise.

■ **FIGURE 1.** Guitar schematic.



You can see the finished wiring of the controls in **Photo 10**. The two black wires are connections to the pickups. The middle heavy wire is the ground for the bridge which is necessary or the guitar will hum when you touch the strings. The wire on the left is the shielded wire going to the output jack.

The orange item between the pots is a 0.047 μF capacitor for the tone control. NOTE: It is very important to have a single ground point for all of the wiring. This helps to eliminate ground loops and hum. Here, all ground connections are soldered to the back of the volume pot.



■ **PHOTO 10.** Control cavity wiring completed. Note all ground connections to the back of the volume pot.

Sustain — Length of time a string vibrates.

Nut — The bit that is between the fingerboard and the headstock that the strings pass over and touch.

Intonation — Refers to the instrument being in tune along the fretboard.

Bridge Pickup — In electric guitars, this is the pickup that is placed closest to the bridge

Neck Pickup — Refers to the pickup closest to the neck.

Humbucker — A noise canceling twin coil pickup normally associated with Fender.

Photo 11 shows the output jack wired up and **Photo 12** shows it mounted into place. **Photo 13** shows the string tree I used for the E and B strings. Its function is to pull these strings downward off of the nut so the strings don't come out of the nut grooves when the guitar is being played hard.



■ **PHOTO 11.** Output jack wired up.



■ **PHOTO 12.** Output jack mounted in place.



■ **PHOTO 13.** String tree mounted for the E and B strings.

Photos 14, 15, and 16 provide various views of the completed guitar. (Isn't it pretty!?!?) In my opinion, it turned out very well.

Additional photos and build information for this guitar are available on my website at www.craigandheather.net/electricguitarpage.html.



■ **PHOTO 14.** Closeup view of the guitar body.

Conclusion

Building this guitar — while not your typical *Nuts & Volts* project — was a lot of fun. Due to the simplicity of design, a guitar like this can be built by most people with sufficient motivation. If you don't possess the necessary tools or the woodworking skills required, maybe a friend or family member does and they can help you build one.

This guitar was not inexpensive to make, however. Much of my expense was a result of my particular choices of guitar components; two top of the line humbucker pickups instead of one, and the use of gold colored hardware drove my price up considerably.

I decided I was only going to do this once, so I might as well use high quality components.

Was it worth it? Definitely yes! Not only do I have a one-of-a-kind guitar that I can say I built myself, but I also have a wonderful sounding instrument that I will get years of use out of.

If you are interested in hearing how this guitar sounds go to **craigandheather.net/songsilike2013cd.html**. You'll find songs off of a CD I did. Every electric guitar part on every song was played on the guitar you see here.

So, that's proof enough that you too can build an electric guitar that sounds every bit as good as one you would buy, but for probably about one tenth the cost.

Plus, there's also the pride that comes from building it yourself. That, my friends, is priceless. **NV**



■ **PHOTO 15.** View from the rear of the guitar. Rear strap button is visible.



■ **PHOTO 16.** Top view of the guitar. The neck plate and front strap button are visible.

AN ELECTRONIC PHOTOCELL FOR LIGHTING CONTROL

By Gerry Shand

I have always been interested in building a circuit that can compute the sunrise and sunset time for use in lighting control without having to rely on the sun like conventional photocell technology does. So, I set out to design a stand-alone circuit so external interfaces like a time signal, GPS input, or a computer interface would be unnecessary. I was also looking for a small but robust design with an LCD where setup is done with two buttons in less than five minutes — as if you were setting a digital watch.



■ **FIGURE 1.** Completed board.

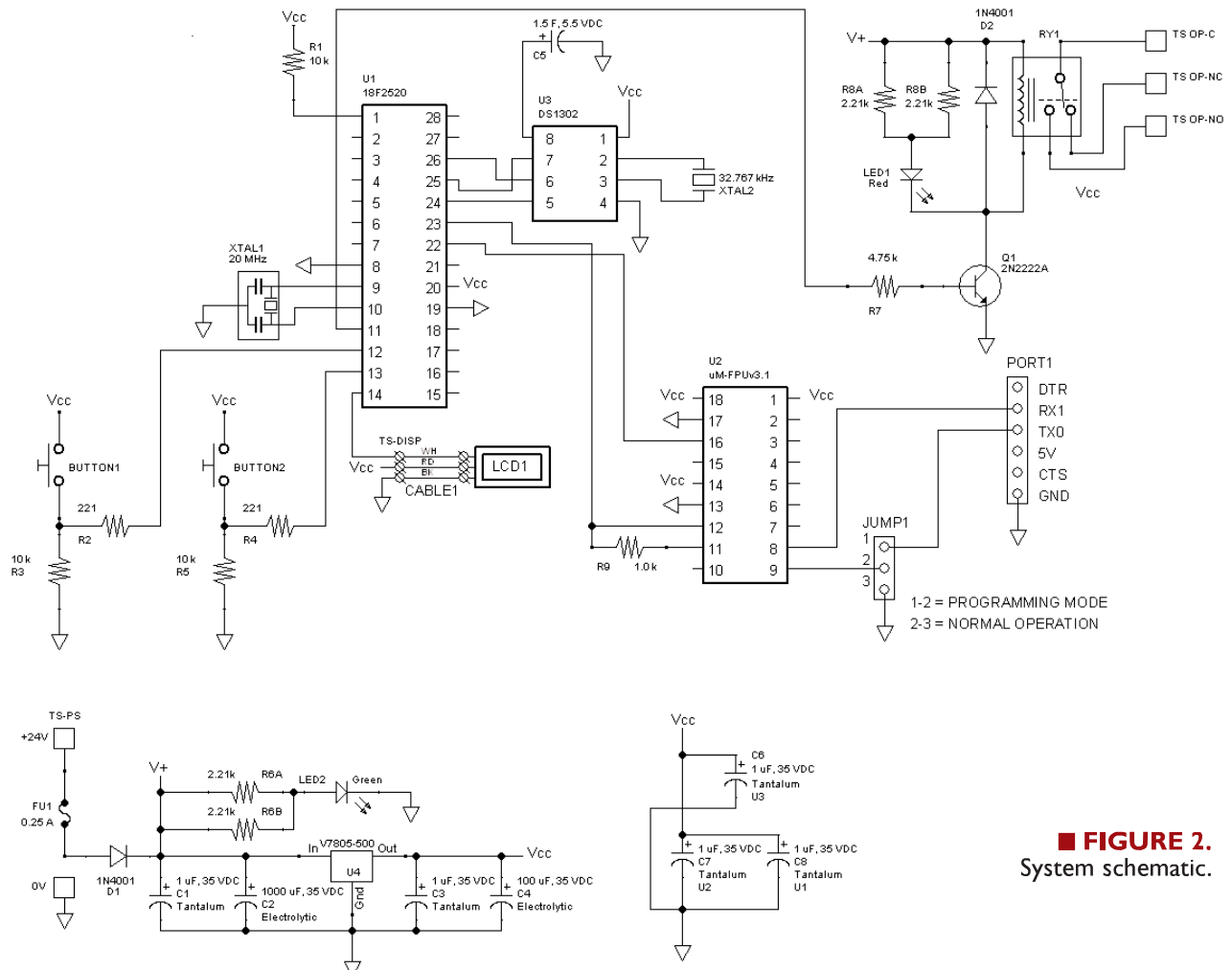
In other words, I wanted something high tech but simple enough to easily replace photocell lighting control because — while cheap — photocells have the following drawbacks:

1. They can be affected by things like shadows, so they have to be mounted carefully — typically, high above the building or object being controlled. This means poking another hole somewhere. This can create a possible issue for security, and the

ingress of moisture and pests.

2. They are susceptible to the effects of vibration, animals trying to take them thinking they are food, and dust/dirt build-up.
3. Wiring issues — while rare — can happen. Long wiring lengths also mean higher installation costs.
4. Mounting them high creates maintenance issues and expensive maintenance costs when they eventually do fail.

The author would like to thank the following for their assistance: Mr. Dave Levesque, Mr. Greg Whiting, Phoenix Contact, Littelfuse, and Digi-Key.



■ **FIGURE 2.**
System schematic.

The Circuit and Schematic Details

Figure 2 is the schematic of the system which has the following:

1. LCD1 is a four-line LCD display with serial interface and 5 VDC supply connected to TS-DISP via a three-wire servo cable. Communications between the display and the circuit are set at 19200 baud.
2. U2 is a μ M-FPUv3.1 coprocessor that handles all the math for computing the sunrise and sunset times. The program code for this is available at the article link. The coprocessor can be programmed on the board using PORT1 and setting JUMP1 per the instructions on the schematic; then using 5V FTDI Basic from www.sparkfun.com. I/O into the PIC is with one pin using R9 as a buffer resistor.
3. U3 is a DS1302 time keeper chip with its own

I did some research, and found the math for computing the sunrise and sunset times at http://williams.best.vwh.net/sunrise_sunset_algorithm.htm. I put this into an Excel spreadsheet to verify the results. A little experimenting shows that setting your position to the nearest degree of longitude and latitude provides a set of results accurate to within a few minutes. This is adequate for lighting systems control.

A little more research found that a real time chip (RTC) and a math coprocessor married to a PIC was the solution I was looking for. The end result is what I call the electronic version of a photocell (shown in **Figure 1**).

So now, I have a board level design that can mount inside a building's electrical room only a few feet from the lighting power supply. This gives me easy access to install, operate, and maintain all control parts of the lighting system.

The sunrise and sunset time is computed every time the board is powered up or at midnight every day, and there is correction for daylight savings time.

PARTS LIST

■ FIGURE 3.

ID#	DESCRIPTION	MFR PART#	MANUFACTURER	SUPPLIER	SUPPLIER PART#
U1	Microcontroller	PIC18F2520-I/SP	Microchip	Digi-Key	PIC18F2520-I/SP-ND
U2	Math coprocessor	µM-FPUv3.1	MicroMega	Parallax	604-00050
U3	Time chip	DS1302+	Maxim	Digi-Key	DS1302+-ND
U4	Voltage regulator	V7805-500	V-Infinity	Digi-Key	102-1709-ND
LED1	Red LED	LN21RPH	Panasonic	Digi-Key	P374-ND
LED2	Green LED	LN31GPH	Panasonic	Digi-Key	P375-ND
Q1	NPN transistor	2N2222A	STM Micro Electronics	Digi-Key	497-2598-ND
D1, D2	Diode	1N4001	Fairchild	Digi-Key	1N4001FSCT-ND
R1, R3, R5	10K, 1%, 0.25W resistor	MFR-25FBB-10K0	Yageo	Digi-Key	10.0KXBK-ND
R2, R4	221 ohm, 1%, 0.25W resistor	MFR-25FBB-221	Yageo	Digi-Key	221XBK-ND
R6A, R6B, R8A, R8B	2.21K, 1%, 0.25W resistor	MFR-25FBB-2K21	Yageo	Digi-Key	2.21KXBK-ND
R7	4.75K, 1%, 0.25W resistor	MFR-25FBB-4K75	Yageo	Digi-Key	4.75KXBK-ND
R9	1.0K, 1%, 0.25W resistor	MFR-25FBB-1K00	Yageo	Digi-Key	1.00KXBK-ND
C1, C3, C6, C7, C8	1 µF, 35V, tantalum capacitor	TAP105M035SCS	AVX	Digi-Key	478-5812-ND
C2	1,000 µF, 35V electrolytic capacitor	ECA-1VM102	Panasonic	Digi-Key	P5169-ND
C4	100 µF, 35V, electrolytic capacitor	ECA-1VM101	Panasonic	Digi-Key	P5165-ND
C5	1.5 µF, 5.5V, super capacitor	EEC-S5R5V155	Panasonic	Digi-Key	P11343-ND
BUTTON1, BUTTON2	N.O. pushbutton	320.01E11YEL	E-Switch	Digi-Key	EG2555-ND
RY1	24 VDC relay, 16A contacts, SPDT	G2R-1-E-DC24	Omron	Digi-Key	Z849-ND
TS-DISP, JUMP1	Three-pole terminal for LCD display	90120-0763	Molex	Digi-Key	WM8085-ND
JUMP1A	Suitcase jumper	382811-8	Tyco	Digi-Key	A26228-ND
PORT1	Six-pole terminal for coprocessor programming	90120-0766	Molex	Digi-Key	WM8088-ND
CABLE1	Three-wire harness for LCD display	805-00001	Parallax	Digi-Key	805-00001-ND
TS-PS	Two-pole screw terminal for power supply	1715721	Phoenix Contact	Digi-Key	277-1263-ND
TS-OP	Three-pole screw terminal for relay output	1715734	Phoenix Contact	Digi-Key	277-1264-ND
SOCKET 1	28-pin DIP socket for U1	1-390261-9	TE Connectivity	Digi-Key	A100210-ND
SOCKET 2	18-pin DIP socket for U1	1-390261-5	TE Connectivity	Digi-Key	A100207-ND
SOCKET 3	Eight-pin DIP socket for U1	1-390261-2	TE Connectivity	Digi-Key	A100204-ND
LCD1	LCD display	27979	Parallax	Digi-Key	27979-ND
XTAL1	20 MHz resonator	CSTLS20M0X53-B0	Murata	Digi-Key	490-1215-ND
XTAL2	32.767 kHz crystal	AB38T-32.768 KHZ	Abrakon	Digi-Key	535-9034-ND
FU 1A	Fuse holder	57100000001	Littelfuse	Digi-Key	WK6225-ND
FU1	0.25A fuse	37202500411	Littelfuse	Digi-Key	WK4235BK-ND
STANDOFF1, 2,3,4	4-40 x 1.25" hex nylon standoff	4808	Keystone Electronics	Digi-Key	4808K-ND
SCREW1,2, 3,4	4-40 x 0.25" steel screw	PMS 440 0025 PH	B&F Fastener Supply	Digi-Key	H342-ND
NUT1,2,3,4	4-40 steel nut	5205821-2	TE Connectivity	Digi-Key	A35230-ND
WASHER1, 2,3,4	#4 nylon washer	3348	Keystone Electronics	Digi-Key	3348K-ND
MOUNT1	Back plane mount for PCB - left	2970442	Phoenix	Digi-Key	2970002-ND
MOUNT2	Back plane mount for PCB - right				
MOUNT3, 4,5,6	Back plane mount for PCB - center 45.00 mm	2970015	Phoenix Contact	Digi-Key	2970015-ND
MOUNT7	Foot mount 1	2970031	Phoenix Contact	Digi-Key	2970031-ND
MOUNT8	Foot mount 2				
PCB1	Printed circuit board	EPC1 Vers 1.1	Shand Power	Shand Power	Not applicable

Notes: The following items are available at www.shandpower.com.

1. The PCB is available for \$75.
2. Pre-programmed ICs U1 and U2 are available for \$82.98.
3. A complete kit with PCB, pre-programmed ICs, and all electronic components is available for \$275.28.
4. A complete kit with PCB, pre-programmed ICs, all electronic components, and the Phoenix mounting components is available for \$317.82.
5. A fully assembled board is available for \$320.28.
6. A fully assembled board with the Phoenix mounting components is available for \$362.82.

All prices include shipping and handling within Canada or the continental United States. Please add 5% for GST. Prices subject to change without notice.

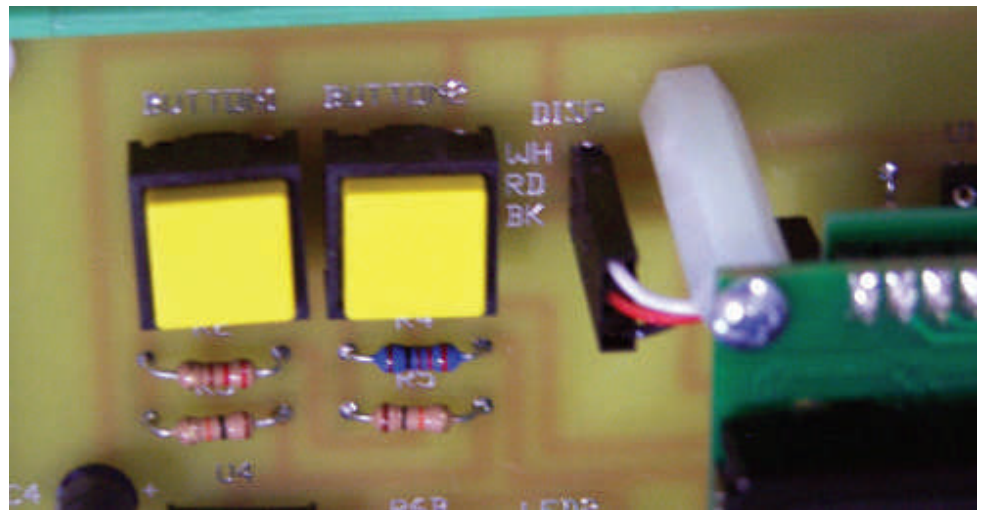
timing crystal XTAL2 and super capacitor C5.
No programming is required.

4. BUTTON1 and BUTTON2 with their respective input (R2 and R4) and pull-down (R3 and R5) resistor networks are used for setup and programming.
5. The output circuit that can be used to turn the lights on and off contains output relay RY1. This relay has 16A contacts rated at 120 VAC, so it could directly control lighting circuits up to 1,500W of connected load; anything larger requires a power interface system. R7, Q1, and D2 act as the interface between the 5 VDC output of the PIC and the 24 VDC coil of the relay. Red LED1 via R8A and R8B serve as an onboard status of the output. When this LED is lit, the output is active signalling that the lights should be turned on.
6. U1 is an 18F2520 PIC processor clocking at 20 MHz from resonator XTAL1. R1 is the pull-up resistor for the reset function. This is the information and control broker since it handles the communications and information exchange to every other part of the circuit. The code for the PIC is also available at the article link and is programmed in before the chip is inserted into the printed circuit board (PCB). Two other PICs were tried, but there were issues with the program size and the best fit turned out to be the 18F2520.
7. A 24 VDC power supply input goes into terminal strip PS. FU1 provides overcurrent protection and D1 provides reverse polarity protection. Power supply status is indicated on the board with green LED2 via resistors R6A and R6B. The 24 VDC bus supplies the power to the output circuit and U4 which is a switching power supply module filtered by C1 and C2. The 5 VDC output is filtered with C3 and C4. I am a huge proponent of power supply filtering, and additional tantalum filtering

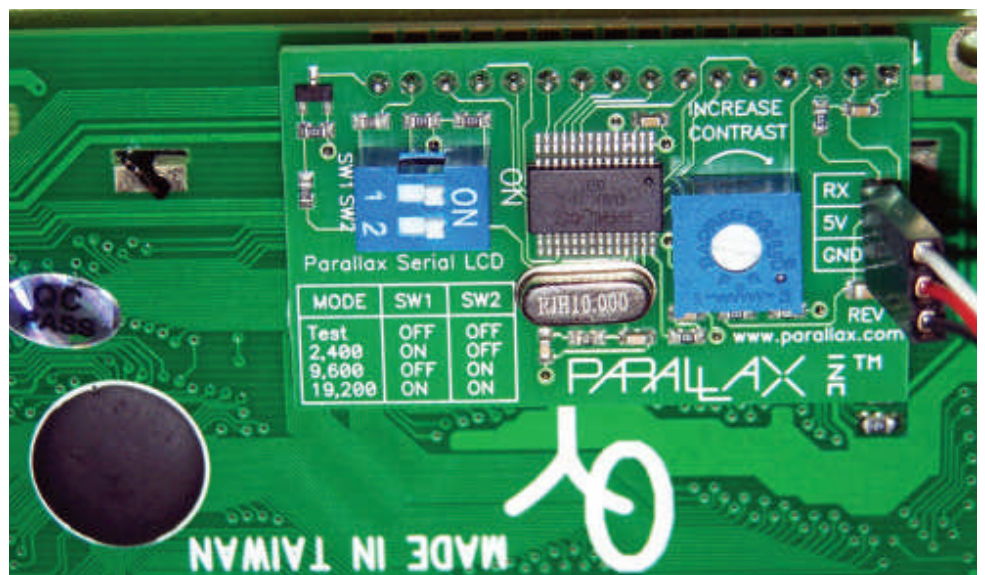
capacitors are provided for U1, U2, and U3 with C8, C7, and C6, respectively. The end result is a rock solid and stable power supply system on the PCB.

8. Provisions for mounting on four 6-32 standoffs or on a PCB carrier that mounts onto the TS35 DIN rail are provided.

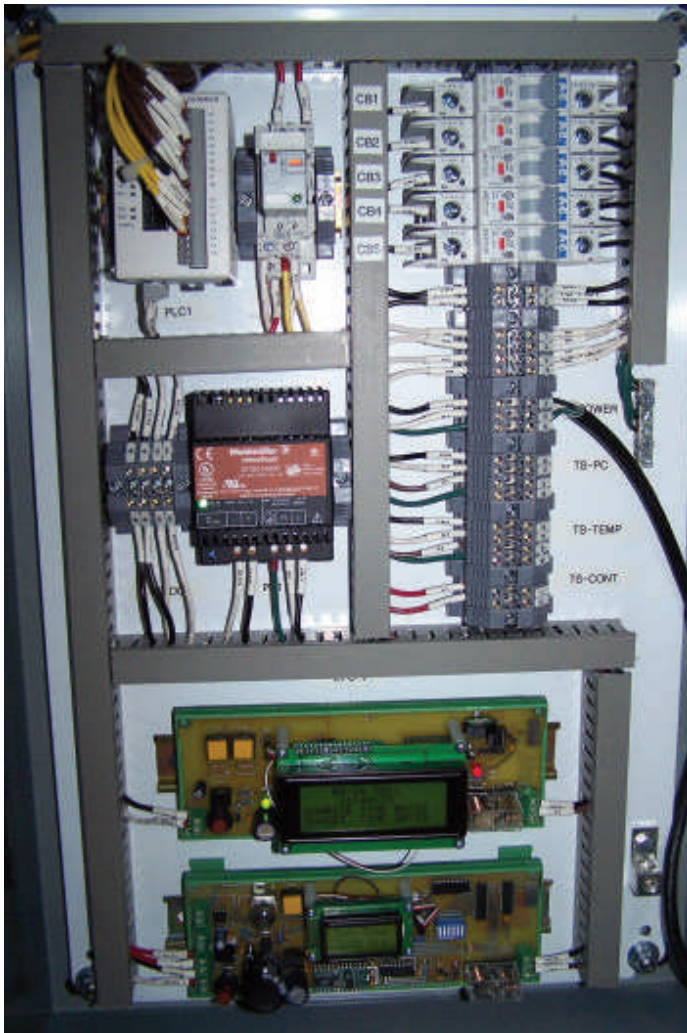
All components are through hole and mount onto one double-sided PCB measuring 7.87" long x 2.82" wide. Board layouts are provided with the downloads. The parts list for the circuit is shown in **Figure 3**. Integrated circuit (IC) sockets are used for U1, U2, and U3, but they could be soldered in. The only tricky part is ensuring CABLE1 is correctly installed on the PCB and on the LCD. **Figures 4A** and **4B** show the correct way of positioning this cable.



■ **FIGURE 4A.** Mounting CABLE1 on the PCB. Note wiring colors called out on the board.



■ **FIGURE 4B.** Mounting CABLE1 on the LCD. Note the white wire goes on the RX pin.



■ **FIGURE 5A.** Industrial lighting controller inside view. EPCI shown near the bottom.



■ **FIGURE 5B.** Industrial lighting controller outside view.

Figure 5 shows the board incorporated into an industrial lighting control panel.

Setup and Programming

Setup is easy but you do need to know the following: time, date, your position in longitude and latitude, and whether the present time in your location is daylight savings time or standard time. You can find your position using a conventional map/atlas or by visiting a website like www.findlatitudeandlongitude.com. Daylight savings and time data can be found at www.timeanddate.com/worldclock. Once you have all this information, board setup consists of the following:

1. After the board goes through its power-up sequence, the following screens are displayed:
 - a. ASTRONOMIC CLOCK
 - b. SYSTEM BUSY...
PLEASE WAIT

- c. READY
- d. MM/DD/YYYY
HH:MM:SS

SUNRISE TIME HH:MM
SUNSET TIME HH:MM

2. Press both BUTTON1 and BUTTON2 at the same time and hold until the following message is displayed:
SET YEAR PRESS 1,
THEN PRESS 2
YYYY
Press BUTTON1 to change that setting as required. Then, press BUTTON2 to toggle the display to show the following message:
3. SET MONTH PRESS 1,
THEN PRESS 2
MM
Press BUTTON1 to change that setting as required. Then, press BUTTON2 to toggle the display to show the following message:

4. SET DATE PRESS 1,
THEN PRESS 2
DD

Press BUTTON1 to change that setting as required.
Then, press BUTTON2 to toggle the display to
show the following message:

5. SET DAYLIGHT SAV. 1,
THEN PRESS 2
ON/OFF

Press BUTTON1 to change that setting as required.
Then, press BUTTON2 to
toggle the display to show the
following message:

6. SET TIME ZONE 1, THEN
PRESS 2
+/- XX

Press BUTTON1 to change
that setting as required. Then,
press BUTTON2 to toggle the
display to show the following
message:

7. SET HOURS PRESS 1, THEN
PRESS 2
HH

Press BUTTON1 to change
that setting as required. Then,
press BUTTON2 to toggle the
display to show the following
message:

8. SET MINS PRESS 1,
THEN PRESS 2
MM

Press BUTTON1 to change
that setting as required. Then,
press BUTTON2 to toggle the
display to show the following
message:

9. SET LATITUDE 1, THEN
PRESS 2
NORTH/SOUTH XXX

Press BUTTON1 to change
that setting as required. Then,
press BUTTON2 to toggle the
display to show the following
message:

10. SET LONGITUDE 1, THEN
PRESS 2
EAST/WEST XXX

Press BUTTON1 to change
that setting as required. Then,
press BUTTON2 to toggle
the display to show the
following message:

11. SET TIME ON BEFORE
SUNSET PRESS 1, THEN
PRESS 2

XX MINUTES

Press BUTTON1 to change that setting as
required. Then, press BUTTON2 to toggle the
display to show the following message:

- 12 SET TIME OFF AFTER
SUNRISE PRESS 1, THEN
PRESS 2

XX MINUTES

Press BUTTON1 to change that setting as required.
Then, press BUTTON2 to toggle the display to

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- USB based. Green PC software



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show the following message:

13. READY

14. After a brief pause, the normal display will be shown as follows:

MM/DD/YYYY
HH:MM:SS
SUNRISE TIME HH:MM
SUNSET TIME HH:MM

A special note about daylight savings time: Once you have set the time, you do not have to go and reset it every time daylight savings time begins or ends. The board will always compute the correct sunrise and sunset time, but half of the year the time of day will display one hour out.

If you feel compelled to change the display time whenever there is a change in daylight savings time, you need to change two parameters: the hour and whether daylight savings time is in effect or not. If you only change one of these parameters, the sunrise and sunset times will be an hour off.

Time zone numbers are the only ambiguous setting here, and are based on how many hours the zone you are in is ahead (+ numbers for Europe, Africa, Asia) or behind

(- numbers for North America, South America, Alaska, and Hawaii) Greenwich Mean Time during standard time. For example: The Mountain Time zone is seven hours behind GMT, so it is set as -7.

Conclusion

This system works very well and has been in use for a couple years without any issues. Other possible applications for this board include:

1. Observing ceremonies and festivals (i.e., Hanukkah and Ramadan) that rely on the sunset and sunrise time of day to start and end the activity.
2. Hunters needing to know when it is sunrise and sunset time, so they know when to begin and end their hunting.

Note: Since the computations are not accurate to the second, I would err on the side of caution and wait about five minutes longer for starting and five minutes sooner for ending an activity. **NV**



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Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs (includes Jaycar stepper motors). Arduino projects can be stand-alone, or they can be communicated with software running on your computer. These Arduino development kits are 100% Arduino-compatible. Designed in Australia and supported with tutorials, guides, a forum and more. A very active worldwide community and resources are available with many projects, ideas and programs available to freely use. Learn more at www.jaycar.us/arduino

Arduino Experimenters Kit

Servo motor, lights, buttons, switches, sound, sensors, breadboard, wires and more are included with a Freetronics Eleven Arduino compatible board in this extensive hobby experimenter and starter kit.

- Comprehensive instructions included
- Size: 340(W) x 165(H) x 36(D)mm

Cat. XC-4262



HOT
SELLER

\$65.00*

Programming Arduino: Getting Started with Sketches

This entry level book explains what an Arduino microcontroller actually is (i.e. a very small stand alone computer), introduces you to the Arduino programming language (called, 'C') and then describes the basic configurations of Arduino modules. After this, the book really begins. It then goes into detail finishing with a discussion on C++ and more sophisticated applications.

- Soft cover, 162 pages.
- Size: 138 x 215mm

Cat. BM-7133



\$15.50*

Getting Started with Arduino Book - 2nd Edition

This book is aimed for the first timer and explains what Arduino is, how it works, and what you can do with it.

- Soft cover, 128 pages.
- Size: 216 x 140mm

Cat. BM-7131



\$20.75*

Arduino-Compatible Shields

8 Channel Relay Driver Shield

Drive up to 8 relays from an Arduino using just 2 I/O pins. It communicates with your board using I2C, so you can even stack several shields together to drive 16, 24, or more outputs!

- Size: 52(W) x 66(H) x 12(D)mm

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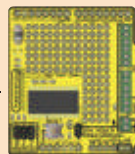
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H-Bridge Motor Driver Shield for Arduino

Directly drive DC motors using your Arduino-compatible board and this shield, which provides PWM (Pulse-Width Modulation) motor output on 2 H-bridge channels to let your board control the speed, direction and power of two motors independently. Perfect for robotics and motor control projects.

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Cat. XC-4264



\$21.75*

Note: Can not included. For comparison only

Arduino-Compatible Boards - Pre Built

"Eleven" Arduino-Compatible Development Board

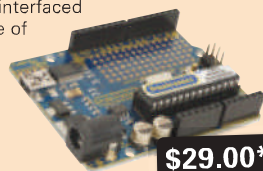
An incredibly versatile programmable board for creating projects. Easily programmed using the free Arduino IDE development environment, and can be connected into your project using a variety of analog and digital inputs and outputs. Accepts expansion shields and can be interfaced with our wide range of sensor, actuator, light, and sound modules.

- 8 analog inputs

Cat. XC-4210

Also available:

ProtoShield Basic (XC-4214 \$3.25*)



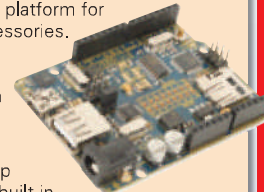
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USBdroid, Arduino-Compatible with USB-Host Support

This special Arduino-compatible board supports the Android™ Open Accessory Development Kit, which is Google's official platform for designing Android™ accessories. Plugs straight into your Android™ device and communicates with it via USB. Includes a built-in phone charger.

- USB host controller chip
- Phone charging circuit built-in
- 8 analog inputs
- microSD memory card slot

Cat. XC-4222



\$50.50*

Large Dot Matrix Display Panel for Arduino

A huge dot matrix LED panel to connect to your Freetronics Eleven, EtherTen and more! This large, bright 512 LED matrix panel has on-board controller circuitry designed to make it easy to use straight from your board. Clocks, status displays, graphics readouts and all kinds of impressive display projects are ready to create with this display's features.

- 32 x 16 high brightness Red LEDs (512 LEDs total) on a 10mm pitch
- 5V operation
- Size: 320(W) x 160(H) x 14(D)mm

Cat. XC-4250



\$29.00*

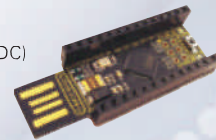
LeoStick (Arduino-Compatible)

A tiny Arduino-compatible board that's so small you can plug it straight into your USB port without requiring a cable! Features a full range of analog and digital I/O, a user-controllable RGB LED on the board and an on-board Piezo/sound generator.

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Cat. XC-4266

Also available: LeoStick Prototyping Shield (XC-4268 \$5.75*)



\$21.75*

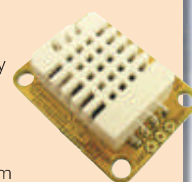
Temperature Modules

Humidity & Temperature Sensor Module for Arduino

Measure temperature and relative humidity using a simple interface that requires just three wires to the sensor: GND, power, and data. Supported by an Arduino library that makes it very easy to read values into your project, so with a single I/O line from your microcontroller you can read both temperature and humidity.

- -4°C to +125°C temperature range with +/-0.5°C accuracy
- 0-100% relative humidity with 2-5% accuracy
- 3 to 5V operation
- Blue power LED
- Size: 31(W) x 23(H) x 4(D)mm

Cat. XC-4246



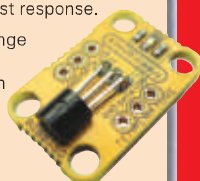
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Temperature Sensor Module for Arduino

Sprinkle these around your house to collect temperature data using your Arduino. This 1-wire bus temperature sensor module is easy to connect and use. You can even daisy-chain several together on the same wire. 0.5°C accuracy and fast response.

- -55 to +125°C temperature range
- +/-0.5°C accuracy
- Selectable 9 or 12 bit precision
- Size: 23(W) x 16(H) x 6(D)mm

Cat. XC-4230



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Don't Just Sit There...Build Something!

THE LOST ART OF STRIP BOARD PROTOTYPING

By Louis Dratwa

These days, we see many forms of ready-to-go development platforms such as the Arduino and Raspberry Pi which are primarily SMT component based. Not long ago, if you wanted a similar device you would build it using a copper clad strip board. One manufacturer of these prototype boards is Vero (www.verotl.com).

Many techs of yester year built their projects on a breadboard, then would transfer everything to a mirror copper clad board. I built a development Vero board project (**Figure 1**) based on the Microchip PIC16F877A-04 10 years ago. Most PICs are still available in through hole packages, along with common transistors, diodes, and resistors.

Having been an electronic technician for over 30 years (and still employed today), I have built countless Vero board circuits for both prototyping and functional every day use. My experience using Vero boards has helped me be a better printed circuit board (PCB) layout designer. I recommend you give these timeless techniques a try.

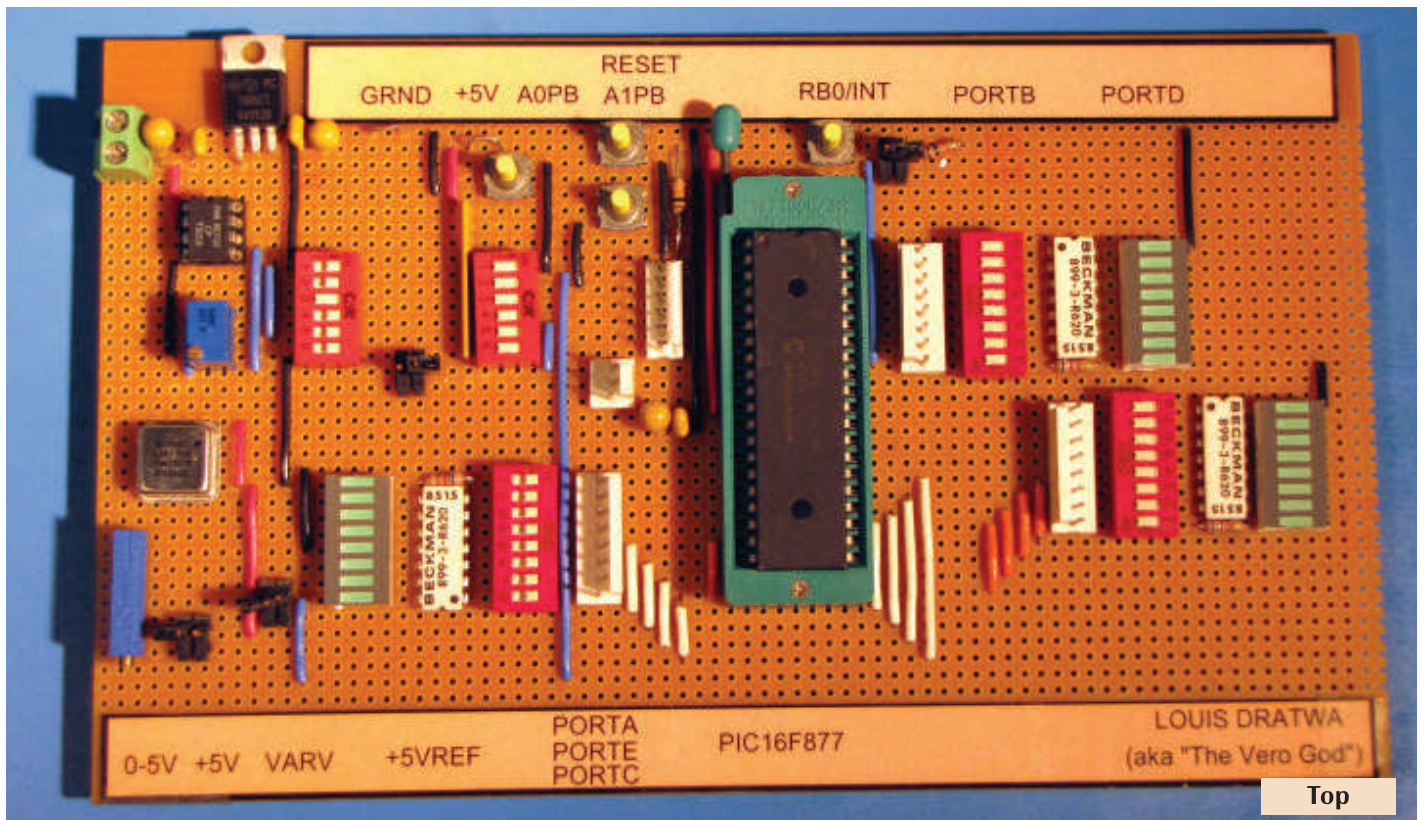
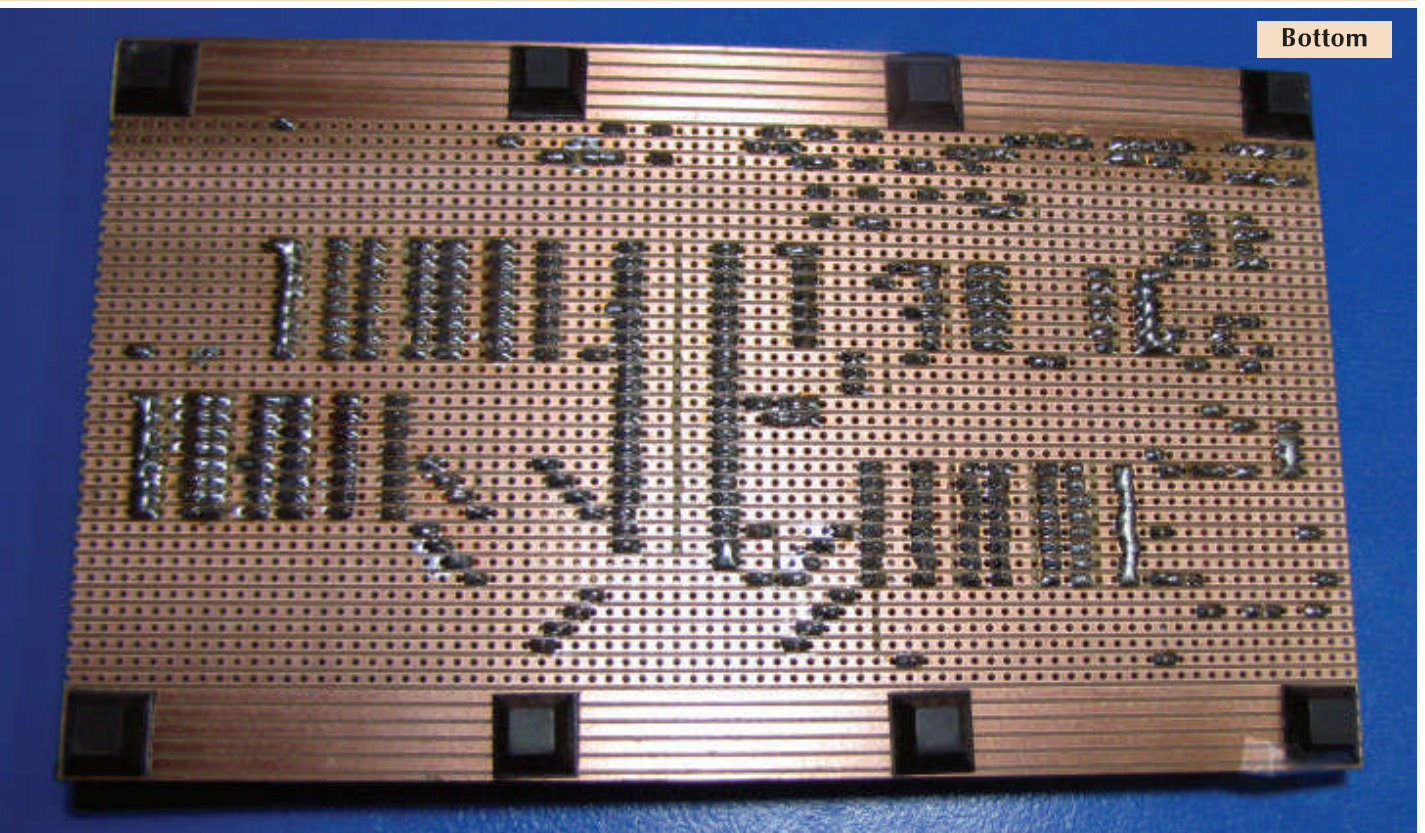


Figure 1. This is how a Vero board ought to look!



VERO BOARD TYPE

I prefer the Vero board type 01-0014 because it has 38 rows of traces with standard .100 inch hole spacing to accept many common electronic packages. It does not match a breadboard exactly, but it is close enough and offers larger sheets than breadboard strip boards. There are also five solid traces along two edges that can be used as power or data buses. These traces can be drilled to accommodate larger size connectors such as .156 IDC (insulation displacement connectors) headers.

PLANNING FOR PROPER SPACE

Having the proper amount of real estate available is the number one consideration when planning a Vero project. Too many Vero projects quickly turn into a crowded nightmare because of poor planning (**Figure 2**). You can also have problems from not “proving” your circuit on a breadboard first.

This step gives you a ball park as to the space required for your project, so helps reduce rework. Don't be afraid to rearrange parts if necessary. You may want to tack a couple of pins down on items like IC sockets, then look if it fits your plan. A good practice is to align all (or as many) of the ICs in the same orientation; this leaves no doubt which way an IC is to be installed. Stay away from leaf IC sockets as they have too many intermittent problems; only use machine IC sockets.

I always give ample room for my projects first and foremost because you or some else may have to troubleshoot and repair the strip board circuit. Secondly, I like to leave extra space for what I call the ECN space. ECN stands for engineering change notice and in my particular line of work, it is prudent to accommodate for this possibility up front. We might have a new variant or an old test that could require improving; this forethought makes changes easy to incorporate.

To help service your Vero creation, it is advisable to create a pictorial parts layout diagram along with your schematic. It can be a simple handdrawn figure or one created on a CAD program.

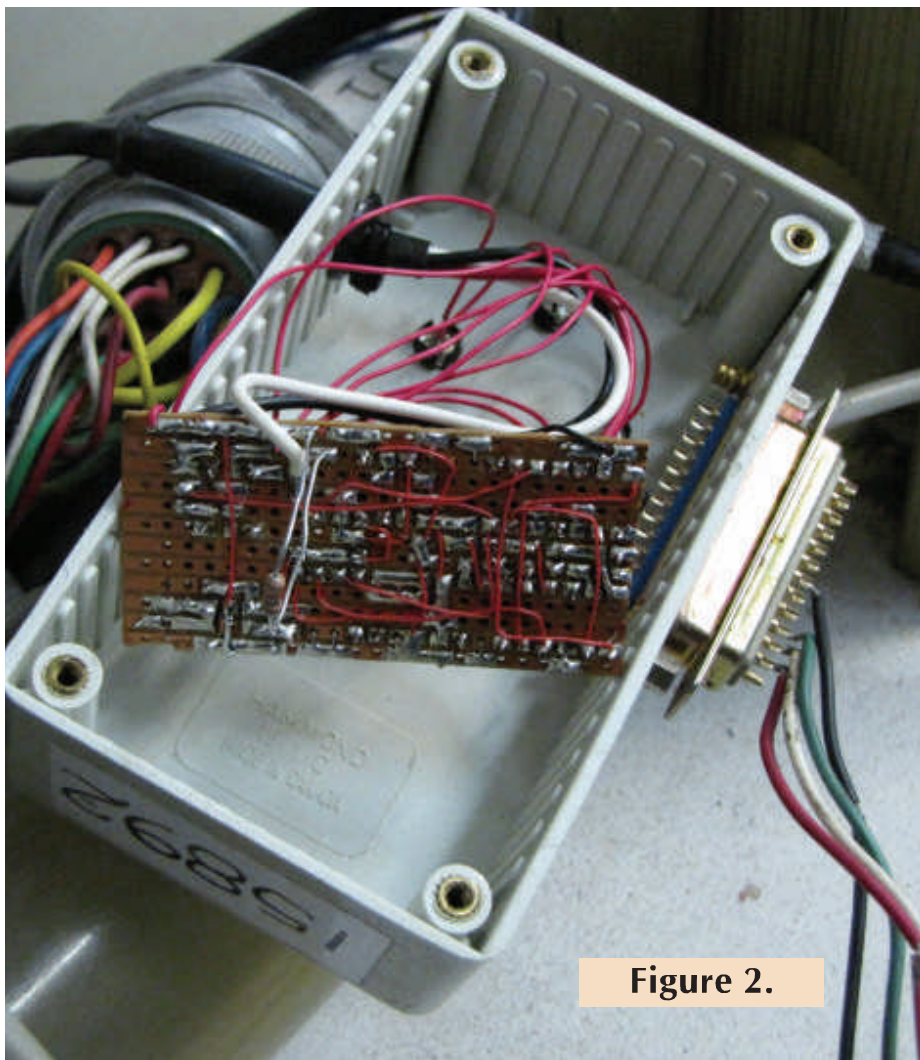


Figure 2.

WIRING VERO

Typical wire used for Vero work is solid 22 gauge. Use at least three colors; for example, red, black, and blue (or any other colors). I use more colors if I need to differentiate analog from digital signals, or for different inputs, outputs, and voltage levels.

A good tip here is to strip one end of the wire, place it in your first hole, run the wire across to the target hole, then dent the insulation with your thumbnail above the hole. This helps stripping the wire at the proper length the first time, and will result in nice tight straight wire lines.

A pair of handheld auto wire strippers helps with large projects, plus gives the wires a clean cut look.

I recommend never running wires or placing components underneath the Vero board because it's a lot easier to just look at the top when doing any troubleshooting. However, this rule can be broken to accommodate items such as .156 headers soldered onto the “strip edge” which will need wire to bring the connections to the through hole traces underneath.

A tip here is to use the middle solid trace (for mechanical stability). Place the .156 header on top of the

copper and scratch its pins into the strip. Use a Dremel drill (a drill press helps big time) and create the required number of holes from the copper side.

Next, you will have to make opens between each pin, but leave enough copper for proper soldering. You may want to remove the first solid copper strip towards the hole strips to prevent any shorts when soldering the wires on to the header. Do not use solid wire with IDCs or for anything “off board.” If the board needs work, just flexing the solid wire to get underneath can cause it to break open.

SOLDERING/CUTTING VERO

Before soldering any device, ensure the copper clad side is fresh and bright. If it is dull and oxidized, use an ultra-fine grit sandpaper to restore it. Strip board is tricky to desolder as the drilled traces tend to lift if too much heat is applied. To avoid this, always use a wet solder tip to conduct the heat quickly when soldering or desoldering.

It is always tempting to bridge over adjacent traces or pins that require connecting when the opportunity arises. Do not go down this road! If rework is required, you may unsolder a connection without realizing it, which will result in wasted time and possibly never getting the board running. If you need to connect adjacent traces, use a bare wire on the component side bent for this purpose.

With more experience, you can leave the small piece of insulation on, but the solder heat has to be perfect because too much will cause the insulation to melt off. There is little metal available to wick away the heat. You may want to make an access point using a raised loop of wire for monitoring power or signals. Vero sells premade loops with colored beads if you want to get fancy. On that note, you may want to use an inexpensive through hole component bender for a more esthetically appearing project.

To keep a nice finished edge when cutting Vero board, always score both sides and align the break with a square table edge; then snap it off. Scoring only one side can result in an uneven break, creating two unattractive pieces of board.

SCREW TERMINALS VS .100 IDCs

It is desirable to use screw terminals for power and any critical measurements since .100 IDCs are not designed for high current. You will find that a typical screw terminal block has pins slightly larger than the Vero board holes.

A tip here is to use a drill bit just a size or two larger than the holes; attach it to a Xacto™ knife tool and hand drill each hole to the desired size.

TIMELESS TIPS

The mating connector to an IDC header requires a special crimp tool to connect stranded wires to it. A work-around is to solder wires directly to the IDC connector. It should be noted that even with the crimp tool available, there are cases where it is advantageous to solder wire directly to the connector. It takes a fine conical solder tipped iron, and you must be careful how long you apply heat and solder. Too long of a time could result in melting the connector or worse ... filling up the cavity that accepts the header pin, rendering the connector useless.

A technique I like is to have a drop of solder on the tip. Contact the top of the metal insert inside of the IDC connector, then add a small amount of solder after contact, and remove. Then, tin the wire and use a wet solder tip to join it to the tinned metal insert.

The use of a handheld auto wire stripper with a strip gauge will keep the stripped wire portion consistent, resulting in a cleaner looking finished product.

Some techs like to use strip board layout software sites available online. I have never used them, but you may want to when first starting out. It may help to just review some layout examples to get going on your own project.

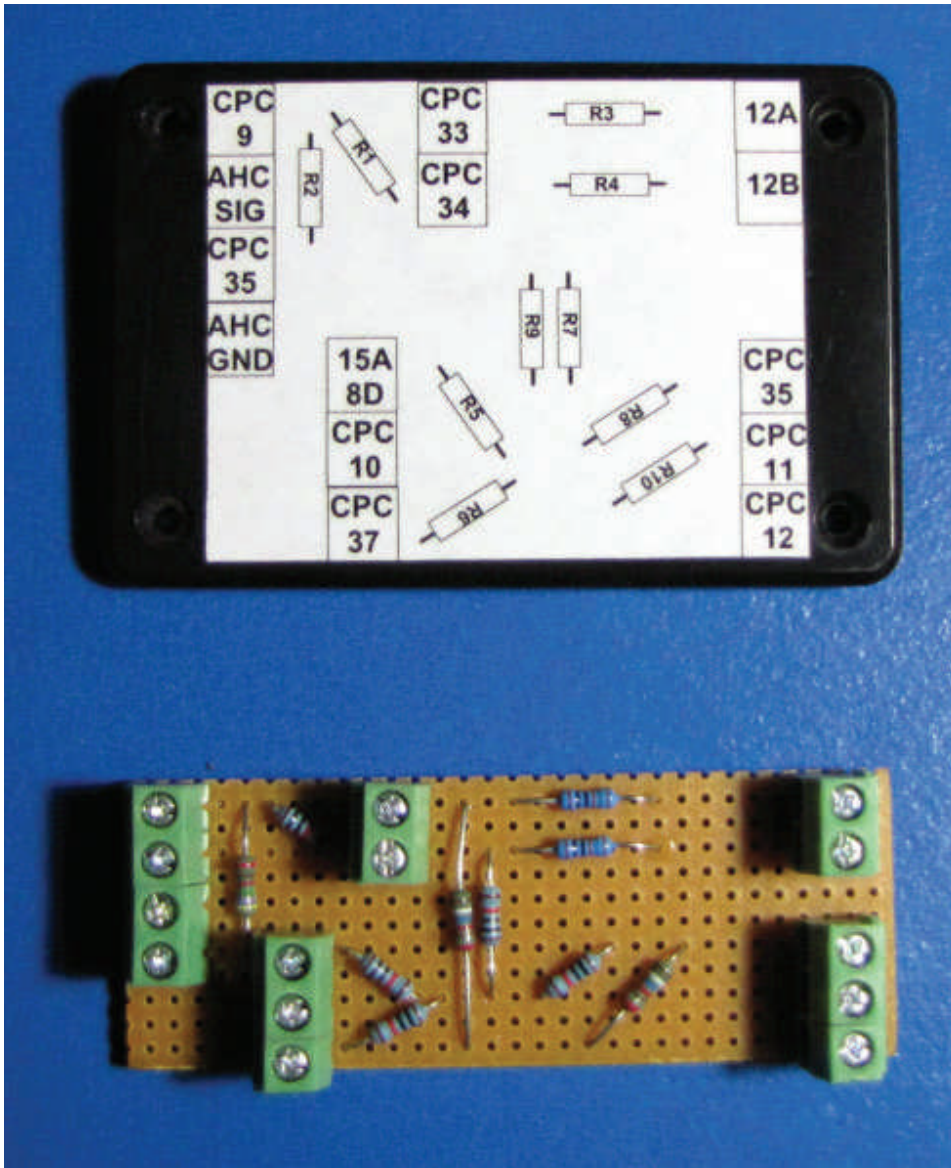
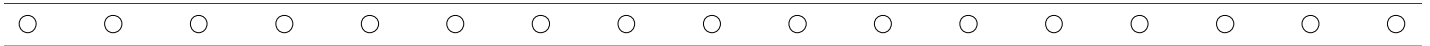
For serviceability, it is great to have all the connections to the Vero board removable, although this might not be practical in some applications. The .100 IDCs are great for LEDs (use integrated LEDs if possible), pushbuttons, connecting logic levels, and to aid in keeping the Vero board removable from all of its wires. IDCs should be avoided when small voltages are used or measured as the contact resistance can cause problems.

HIGH CURRENT DEVICES

High current devices can be accommodated by

BENEFITS OF WORKING WITH VERO BOARD

- Improve your design, hardware, and soldering skills.
- Valuable experience when you want to design PCBs.
- Meeting time constraints that don't allow for a PCB to be designed.
- Creating an add-on circuit to an existing PCB that requires modification.
- A valuable skill set whether a hobbyist or tech.



Pictorial example.

beefing up the copper traces with solder. Of course, you must take care not to short out adjacent traces. I've seen almost invisible solder strands short traces out. It is a good practice to run a small slot screwdriver between the traces, followed by a hard brushing of the finished solder side with a stiff horse hair brush. Of course, give it a visual check for shorts, cold solder joints, missed solder connections, and areas that should be beefed up with solder but were missed. It is also a good practice to "ohm out" power for shorts. Do all of this before powering up for the first time.

When calculating a fuse size for your project, consider all high current devices and current surges. Incandescent bulbs will produce a current surge until the filaments heat up and offer resistance. The use of a slow blow fuse here may be required. For most of my Vero projects, I use poly

switches in place of fuses, as they reset themselves and do not require replacing if the current rating has been calculated properly.

CREATING OPENS

Just as important as a good connection is a proper open trace. I have seen some opens created by a space barely wider than an Xacto blade thickness. These may work at first, but as the Vero ages it shrinks. So, what was an open is now a bothersome intermittent headache.

When creating an open, I recommend removing one hole width of copper. Smaller widths will work but are not as visual or consistent when compared to removing a "whole" hole width.

The use of a two- or three-pin header gives the option of selecting which function you want by using a .100 shorting clip. I typically use four two-pin headers on my Vero development boards; here, one selects between Port B0 and INT (Interrupt). Other uses could include selecting whether an input is pulled up or down.

MOUNTING VERO

Mounting Vero board in project enclosures can be accomplished by custom cutting it to a size that will fit the circuit board receiver slots inside the case. This makes it easy to remove for servicing. Be sure to use

the proper size case to avoid a crowded Vero board circuit (refer again to **Figure 2**). Other methods include using standoffs and drilling holes to accommodate them.

If you're not using the five solid traces on the edge, this is a good place to drill the holes. Some designs are too small and one must drill the hole traces for mounting. Remove enough copper so nothing shorts to the standoffs, and don't drill too close to any edge. You would think this is a clear concept, but I have seen many Vero problems from not addressing these issues properly.

IN-CIRCUIT SERIAL PROGRAMMING

If I built this particular Vero board project today, I

DOS AND DON'TS WHEN BUILDING A VERO STRIP BOARD CIRCUIT

Do beef up high current traces with solder.
Don't use solid wire to connect to devices off the Vero board.

Do run a small slot blade screw driver between traces to remove hair size shorts after building.
Don't bridge two pins or traces with solder; always use a wire jumper on the component side.

Do take out one "hole width" when creating an open.
Don't jam too many parts on a small board; estimate your real estate beforehand.

Do use "back EMF" diodes on all relay coils and inductive loads.
Don't make short wires to panel mounted devices; supply enough length to access the Vero board

Do attempt to align all the ICs in the same orientation.
Don't mark up your board with felt pen to highlight power buses; use proper wire colors instead.

Do create loops of solid wire to monitor power and signals.
Don't use an old board with tarnished copper; brighten copper with fine sandpaper.

Do use IDCs for LEDs, logic level signals, pushbuttons, and switches.
Don't use IDCs for power, critical measurements, and high current devices; use screw terminals.

Do create both pictorial and schematic diagrams for servicing your Vero project.
Don't desolder with a dry tip; use a wet tip when using solder wick.

Do fuse your power on or off board; poly switches can be used, as well.
Don't use leaf IC sockets; use machine sockets only.

Do breadboard the circuit first to plan for space and reduce rework.
Don't solder wires or components on the solder/copper side.

would add an ICSP (In-Circuit Serial Programming) five-pin IDC header for downloading source code. All of my PIC16F877A-04 based PCB (printed circuit board) projects have this feature which is connected to a DB9 connector on the chassis of the project.

THAT'S A WRAP

There are many opinions about when, where, or if to use Vero vs. designing a PCB. The majority of negative experiences involving strip board use originate from the lack of skill creating the strip board circuit. If built properly, a Vero board design can be just as reliable when compared to a PCB.

It is important to follow the guidelines presented here, however, being flexible and adapting to new situations is important too. This may require ignoring a rule or practice to build the best possible Vero board circuit. **NV**

Louis Dratwa can be reached at vboard@shaw.ca.



TAMING THE DUALSHOCK 3 BEAST

The PlayStation DualShock 3 was initially designed as a user interface for the PlayStation gaming system. Fortunately for us, Sony decided to design the DualShock 3 around the USB HID specification. HID devices do not normally require any specialized operating system-dependent drivers. Using the HID specification potentially allows the DualShock 3 to connect to most any USB host device. This works to our advantage. The Microchip USB stack supports standard HID protocols hosted by PIC32MX microcontrollers. All we have to do is determine what the DualShock 3 wants to hear, and get the messages through via a HID-based USB link.

SNAKES AND PENGUINS

Despite the snake problem we are now enduring in the Florida Everglades, uttering the word Python is not all bad. The “bad” pythons are quickly gobbling up our four-legged critters (alligators included). The “good” pythons aren’t really snakes at all. These “Pythons” that don’t coil and swallow deer whole represent a programming language.

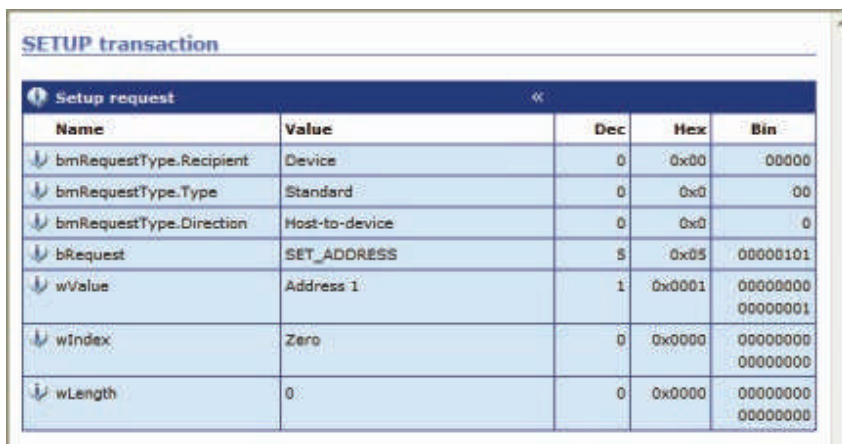
Unlike leopard seals, sharks, and killer whales, Python (the programming language) does not prey on penguins. The penguin described here doesn’t slide on ice and eat cold fish. The penguin represents the operating system we call Linux.

In that our “animals” are really units of logic, we could logically state that, in this case, the snake talks to

the penguin. We could also look at it from the reverse perspective and state that the penguin eats the snake. (Let’s not go there.) To give us some clues as to how to code our PIC32MX USB host, we must listen to the snake too. For instance, this hissing will come in handy later:

```
const unsigned char
enable_SIXAXIS[] =
{0x03, 0xF4, 0x42, 0x0C, 0x00, 0x00}
;
```

As we work our way through the PIC32MX PlayStation DualShock 3 client driver code, we will depend heavily on the snakes in the grass. We’ll also use all of the hardware technology and applications available to us to fill in the bits and bytes of information that the snakes and penguins won’t share with us. The Ellisys USB Explorer 200 and MotionJoy Gamepad Tool will be very busy.



SETUP transaction

Setup request				
Name	Value	Dec	Hex	Bin
bmRequestType.Recipient	Device	0	0x00	000000
bmRequestType.Type	Standard	0	0x0	00
bmRequestType.Direction	Host-to-device	0	0x0	0
bRequest	SET_ADDRESS	5	0x05	00000101
wValue	Address 1	1	0x0001	00000000 00000001
wIndex	Zero	0	0x0000	00000000 00000000
wLength	0	0	0x0000	00000000 00000000

■ SCREENSHOT 1. It is very important to know the device address that gets assigned to the PlayStation DualShock 3. The Microchip USB stack takes care of the device addressing task automatically.

WHAT WE ALREADY KNOW

The MotioninJoy tool works in conjunction with Windows to drive a DualShock 3 directly from a host PC's USB portal. We will use the Explorer 200 to capture everything USB that flows between the PC and the attached DualShock 3. The plan is to record all of the USB packets in their order of appearance. This will give us a clear view of the USB events that are necessary to communicate with the DualShock 3. The USB trace will begin as soon as I attach the DualShock 3 to the PC's USB portal.

Screenshot 1 is a graphical view of the USB packet that is sent from the host to assign an address to the DualShock 3. It is imperative to know the DualShock 3's device address as we will use it to route USB packets destined for it. Note that our assigned DualShock 3 device address is 1. We already know that the USB stack will take care of assigning a device address. Odds are that the USB stack will also anoint the DualShock 3 as device number 1.

Some applications want to know the device's name. The device name is contained within the iProduct string. As you can see in **Screenshot 2**, the iProduct field does not contain the data. However, the iProduct field does *point* to the data. The host requests the iProduct string in **Screenshot 3** using the index value (02) of the wValue field (0x0302).

Before we leave **Screenshot 2**, there are a few more things we need to be aware of. The maximum packet size we can force through endpoint 0 is 64 bytes, as notated in the bMaxPacketSize0 field. Things can't get too complicated since we only have one device configuration to work with.

That configuration alluded to in the bNumConfigurations field of **Screenshot 2** is outlined in the upper window of **Screenshot 4**. Basically, the Configuration descriptor is telling us that the DualShock 3's USB innards consist of a bus powered single interface that wants permission to draw a maximum of 500 mA of current. The HID (Human Interface Device) interface (interface 0) supports two endpoints. A control endpoint also exists which is not specified in the Interface descriptor. The DualShock 3 endpoint types and addresses are shown in **Screenshot 5**. Each of the interrupt endpoints supports a maximum of 64 bytes per packet. The next thing the HID host driver does is set the configuration. Since we only have one configuration, **Screenshot 6** is an easy read. The Explorer 200 picks up a

GetDescriptor (Device)

Device descriptor				
Name	Value	Dec	Hex	Bin
bLength	18	18	0x12	00010010
bDescriptorType	DEVICE	1	0x01	00000001
bcdUSB	2.0	512	0x0200	00000010 00000000
bDeviceClass	Class defined at interface level	0	0x00	00000000
bDeviceSubClass	Subclass defined at interface level	0	0x00	00000000
bDeviceProtocol	None	0	0x00	00000000
bMaxPacketSize0	64	64	0x40	01000000
idVendor	Sony Corporation	1,356	0x054C	0000101 01001100
idProduct	Batch Device	616	0x0268	00000010 01101000
bcdDevice	1.0	256	0x0100	00000001 00000000
iManufacturer	1 "Sony"	1	0x01	00000001
iProduct	2 "PLAYSTATION(R)3 Controller"	2	0x02	00000010
iSerialNumber	0	0	0x00	00000000
bNumConfigurations	1	1	0x01	00000001

■ **SCREENSHOT 2.** This beats fumbling through hex dumps. So, when possible, I'll present our USB discoveries in this manner. The content of this capture includes the PlayStation DualShock 3's idVendor (VID) and idProduct (PID) data.

SETUP transaction

Setup request				
Name	Value	Dec	Hex	Bin
bmRequestType.Recipient	Device	0	0x00	000000
bmRequestType.Type	Standard	0	0x0	00
bmRequestType.Direction	Device-to-host	1	0x1	1
bRequest	GET_DESCRIPTOR	6	0x06	00000110
wValue	STRING (2)	770	0x0302	00000011 00000010
wIndex	English (US)	1,033	0x0409	00000100 00001001
wLength	255	255	0x00FF	00000000 11111111

■ **SCREENSHOT 3.** The key to understanding how the iProduct string is retrieved is to break down the 0x0302 wValue field. The 03 tells us that it is a string and the 02 is the string index. The string's index value is stored in the iProduct field in Screenshot 2.

series of *GetReport* USB events following the *SetConfiguration* event. We could detour here for days examining the structure and content of report descriptors. I don't think we'll need to dig that deeply into report descriptors at this point, however. So, to continue, let's look for something that the snakes and penguins have previously described to us.

THE PENGUIN SPEAKS

As I browsed the Explorer 200 trace, a particular

SetReport event caught my eye. The hexadecimal sequence 0x42 0x0C 0x00 0x00 I came across in the trace is identical to a portion of the Linux code that enables the DualShock 3, which is also known as *SIXAXIS*. Thus far, all of the communications between the DualShock 3 and the PC have used the control endpoint (endpoint 0). That tells us that all of the USB traffic up to this point has been in the form of setup and commands. Report data moves on the pair of interrupt endpoints.

Digging deeper into the trace, I discovered another enable function payload hexadecimal match of 0x03 0xF4. The Setup transaction you see in **Screenshot 7** is telling us that four bytes of data is to be sent to the DualShock 3 interface. These four bytes to be sent consist of the *SIXAXIS* enable string (0x42 0x0C 0x00 0x00). None of this will fall

together and make any sense until we can map those hex characters to a corresponding USB stack function call. Using the Setup transaction field names, I found a stack function that just might work. Here are its parameters:

Parameters:

```

BYTE deviceAddress - Device address
BYTE bmRequestType - The request type as defined by the USB specification.
BYTE bRequest - The request as defined by the USB specification.
WORD wValue - The value for the request as defined by the USB specification.
WORD wIndex - The index for the request as defined by the USB specification.
WORD wLength - The data length for the request as defined by the USB specification.
BYTE *data - Pointer to the data for the request.
BYTE dataDirection - USB_DEVICE_REQUEST_SET or USB_DEVICE_REQUEST_GET
BYTE clientDriverID - Client driver to send the event to.
```

The stack function that belongs to the aforementioned parameters is defined as follows:

```

BYTE USBHostIssueDeviceRequest(
    BYTE deviceAddress, BYTE bmRequestType,
    BYTE bRequest, WORD wValue, WORD wIndex,
    WORD wLength, BYTE *data, BYTE
    dataDirection,
    BYTE clientDriverID )
```

The function name and arguments appear to be in line with the call we will have to issue to send those four bytes of *SIXAXIS* enable data.

THE SNAKE IS HISSING

The 48-byte hex dump that follows is actually the contents of a buffer that is sent as a report to the DualShock 3. I found this in a Python listing:

```

0x00, 0x00, 0x00, 0x00, 0x00,
// rumble control
0x00, 0x00, 0x00, 0x00, 0x00,
// LED Control
0xFF, 0x27, 0x10, 0x00, 0x32,
// LED4
0xFF, 0x27, 0x10, 0x00, 0x32,
// LED3
0xFF, 0x27, 0x10, 0x00, 0x32,
// LED2
0xFF, 0x27, 0x10, 0x00, 0x32,
// LED1
0x00, 0x00, 0x00, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x00,
0x00, 0x00, 0x00
```

The Explorer 200 captured the packet payload in this configuration:

```

0x00, 0x96, 0x00, 0x96, 0x00,
// rumble control
0x00, 0x00, 0x00, 0x00, 0x02,
// LED Control
```

GetDescriptor (Configuration)				
Configuration descriptor				
Name	Value	Dec	Hex	Bin
bLength	Valid	9	0x09	00001001
bDescriptorType	CONFIGURATION	2	0x02	00000010
wTotalLength	41 bytes	41	0x0029	00000000 00101001
bNumInterface	1	1	0x01	00000001
bConfigurationValue	1	1	0x01	00000001
iConfiguration	0	0	0x00	00000000
bmAttributes, Reserved	Zero	0	0x00	000000
bmAttributes, RemoteWakeup	Not supported	0	0x0	0
bmAttributes, SelfPowered	No, Bus Powered	0	0x0	0
bmAttributes, Reserved7	One	1	0x1	1
bMaxPower	500 mA	250	0xFA	11111010

Interface descriptor				
Name	Value	Dec	Hex	Bin
bLength	Valid	9	0x09	00001001
bDescriptorType	INTERFACE	4	0x04	00000100
bInterfaceNumber	0	0	0x00	00000000
bAlternateSetting	0	0	0x00	00000000
bNumEndpoints	2	2	0x02	00000010
bInterfaceClass	Human Interface Device (Find out more online)	3	0x03	00000011
bInterfaceSubClass	Unknown (0x00)	0	0x00	00000000
bInterfaceProtocol	None	0	0x00	00000000
iInterface	0	0	0x00	00000000

HID descriptor	
bCountryCode	Not Supported
bNumDescriptors	1
bDescriptorType[0]	REPORT
wDescriptorLength[0]	148 bytes

■ **SCREENSHOT 4.** USB descriptors aren't very difficult once you understand how they support each other. The Configuration descriptor informs us about the interfaces and configurations. The Interface descriptor lays out the endpoints. The endpoints are described in their respective descriptors.

```

0xFF, 0x27, 0x10, 0x00, 0x32,
// LED4
0xFF, 0x27, 0x10, 0x00, 0x32,
// LED3
0xFF, 0x27, 0x10, 0x00, 0x32,
// LED2
0xFF, 0x27, 0x10, 0x00, 0x32,
// LED1
0x00, 0x00, 0x00, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x00,
0x00, 0x00, 0x00

```

There is a rumble motor in each of the DualShock 3 handles. The Python hexadecimal dump is set up to turn the rumble motors off. Here is how the bytes in the rumble control line correspond to the rumble motors:

```

0x00, RIGHT MOTOR TIMEOUT, RIGHT MOTOR
FORCE, LEFT MOTOR TIMEOUT, LEFT MOTOR
FORCE

```

With that, note that the Explorer 200 capture tells us that the gamepad tool set the rumble motor timeouts and cleared the motor force fields.

The DualShock 3 is fitted with a quad of LEDs that can be found to the left of the USB connector. The value of the far right byte of the LED control hex line determines which LEDs are illuminated. An LED is illuminated when its respective bit is set. Here is the LED truth table:

```

0x00 - All LEDs OFF
0x02 - LED1 ON
0x04 - LED2 ON
0x08 - LED3 ON
0x10 - LED4 ON

```

The Python hexadecimal dump extinguishes the quad of LEDs. The DualShock 3 LED control byte captured with the Explorer 200 (0x02) indicates that LED1 is to be illuminated. This LED configuration (LED1 ON) is sometimes used to tell the user that the DualShock 3 is connected and working as designed. The Setup transaction that makes the DualShock 3 rumble and blink is displayed in **Screenshot 8**. We can use the same `USBHostIssueDeviceRequest` function that we will use to enable the DualShock 3 to control the rumble motors and LEDs.

A 49-byte per packet data stream appeared about 9 ms after the rumble/LED data packet was transmitted. Before we make any attempt to interpret the reports sent by the DualShock 3, let's make sure we can get the same results using a PIC32MX and the USB stack.

TIMING IS EVERYTHING

Let's begin by setting up the report request timer. I noted that the reports from the DualShock

(Find out more online)

HID descriptor				
Name	Value	Dec	Hex	Bin
bLength	Valid	9	0x09	00001001
bDescriptorType	HID	33	0x21	00100001
bcdHID	1.1.1	273	0x0111	00000001 00010001
bCountryCode	Not Supported	0	0x00	00000000
bNumDescriptors	1	1	0x01	00000001
bDescriptorType[0]	REPORT	34	0x22	00100010
wDescriptorLength[0]	148 bytes	148	0x0094	00000000 10010100

Endpoint descriptor				
Name	Value	Dec	Hex	Bin
bLength	Valid	7	0x07	00000111
bDescriptorType	ENDPOINT	5	0x05	00000101
bEndpointAddress	2 OUT	2	0x02	00000010
bmAttributes, TransferType	Interrupt	3	0x3	11
bmAttributes, Reserved	Zero	0	0x00	00000000
wMaxPacketSize	64 bytes	64	0x0040	00000000 01000000
bInterval	1 frame (1000 us)	1	0x01	00000001

Endpoint descriptor				
Name	Value	Dec	Hex	Bin
bLength	Valid	7	0x07	00000111
bDescriptorType	ENDPOINT	5	0x05	00000101
bEndpointAddress	1 IN	129	0x81	10000001
bmAttributes, TransferType	Interrupt	3	0x3	11
bmAttributes, Reserved	Zero	0	0x00	00000000
wMaxPacketSize	64 bytes	64	0x0040	00000000 01000000
bInterval	1 frame (1000 us)	1	0x01	00000001

■ **SCREENSHOT 5.** Everything we need to know about the endpoints is here. Remember that every HID USB device also has an endpoint 0, which is known as the control endpoint.

SETUP transaction

Setup request				
Name	Value	Dec	Hex	Bin
bmRequestType.Recipient	Device	0	0x00	000000
bmRequestType.Type	Standard	0	0x00	00
bmRequestType.Direction	Host-to-device	0	0x00	0
bRequest	SET_CONFIGURATION	9	0x09	00001001
wValue	Configuration 1	1	0x0001	00000000 00000001
wIndex	Zero	0	0x0000	00000000 00000000
wLength	0	0	0x0000	00000000 00000000

■ **SCREENSHOT 6.** This makes that single configuration official. The Recipient, Type, and Direction fields are very important as they are the routing variables for the `SET_CONFIGURATION` request.

3 were requested at 10 mS intervals. If it's good enough for Windows, it's good enough for us. Here's the PIC32MX timer code:

```

/*****
/* INITIALIZE THE IN REPORT TIMER
*****/
void InitializeTimer(void)
{
    T4CON = 0x0;      //Stop and Init Timer
    T4CON = 0x0050;    //prescaler = 1:32 -
                      //internal clock
    TMR4 = 0;         //Clear timer register
    PR4 = 0x61A8;      //Load period register -
                      //0.010 second period

    IPC4SET = 0x00000005; // Set priority
                      //level=1

    IFS0bits.T4IF = 0;
    IEC0bits.T4IE = 1;

    T4CONSET = 0x8000;    //Start Timer
}

```

The PR4 period register value is calculated as follows:

```

Timer Clock = 80 MHz
Prescaler = 1:32
Desired Interval = 0.010 seconds
PR4 = ?

1 raw timer tick time = 1/80000000 = 0.000000012
seconds
1 prescaled timer tick time = 32 * 0.000000012 =
0.000000400 seconds

PR4 = 0.010 / 0.000000400 = 25000 = 0x61A8

```

Every 10 mS, *Timer4* will overflow and generate an interrupt. The interrupt handler's job is to place the PIC32MX application in the proper state to retrieve a report from the DualShock 3. The *Timer4* interrupt handler looks like this:

```

/*****
/* IN REPORT TIMER INTERRUPT HANDLER
*****/
#pragma interrupt _T4Interrupt ipl4 vector 16
void _T4Interrupt( void )
{
    if (IFS0bits.T4IF)
    {
        IFS0bits.T4IF = 0;
        //mPORTAToggleBits(BIT_0);
        if (READY_TO_TX_RX_REPORT == PS3State)
        {
            PS3State = GET_INPUT_REPORT;
        }
    }
}

```

I used the *mPORTAToggleBits(BIT_0)* function to toggle the RA0 I/O pin. If you want to check my math, uncomment the toggle bit function and put a scope to RA0. As they say, numbers don't lie.

TAKEOFF ROLL

The PIC32MX is supported by a number of libraries that are designed to help the programmer get the most out of the 32-bit silicon. With that, the first thing we will do is code in some PIC32MX functions that will maximize the microcontroller's performance. The next bit of coding will kick off the PIC32MX timing mechanisms and interrupt engine. Finally, we will fire up the UART and set it up to run at 115200 bps. All of this startup code can be found in the *init()* function:

```

/*****
/* INITIALIZE FUNCTION
*****/
void init(void)
{
    int value;

    value = SYSTEMConfigWaitStatesAndPB(
        GetSystemClock() );

    // Enable the cache for the best performance
    CheKseg0CacheOn();
    // Enable Interrupts
    INTEnableSystemMultiVectoredInt();
    // Wait for PLL lock to stabilize
    value = OSCCON;
    while (!(value & 0x00000020))
    {
        value = OSCCON;
    }

    // Uncomment next 2 lines to check 10 mS
    //timer on RA0
    //mJTAGPortEnable(DEBUG_JTAGPORT_OFF);
    //mPORTASetPinsDigitalOut(BIT_0);

    //Initialize UART
    setbuf(stdout, NULL); //UART1 REDIRECT

    UARTConfigure(UART1, UART_ENABLE_PINS_
        TX_RX_ONLY);
    UARTSetFifoMode(UART1, UART_INTERRUPT_
        ON_TX_NOT_FULL | UART_INTERRUPT_ON_
        RX_NOT_EMPTY);
    UARTSetLineControl(UART1, UART_DATA_
        SIZE_8_BITS | UART_PARITY_NONE |
        UART_STOP_BITS_1);
    UARTSetDataRate(UART1, GetPeripheral
        Clock(), 115200);
    UARTEnable(UART1, UART_ENABLE_FLAGS
        (UART_PERIPHERAL | UART_RX | UART_TX));

    PS3State = DEVICE_NOT_CONNECTED;
}

```

This puppy is ready to fly.

GEAR UP

Let's walk through the DualShock 3 client driver code in sequence, beginning with the call to initialize the hardware and USB engine:

Digilent
chipKIT Max32
chipKIT Network Shield
www.digilentinc.com

Ellisys
Ellisys USB Explorer 200
Protocol Analyzer
www.ellisys.com

Microchip
XC32 C Compiler
Microchip USB Stack
www.microchip.com

Sony
PlayStation DualShock 3
Controller
www.sony.com

```

//*****
// MAIN
//*****
int main (void)
{
    BYTE i;
    init();
    USBInitialize(0);

```

The USB stack requires a periodic call to *USBTasks()*. So, we'll do that every time we enter the beginning of the state machine loop. Nothing meaningful will happen if we don't physically attach the DualShock 3 to the chipKIT Max32's host USB portal, however. Our code will call the USB stack's *USBHostHIDDeviceDetect(1)* function until a DualShock 3 is detected. The *USBHostHIDDeviceDetect(1)* function's argument of one represents the device address of the DualShock 3. Once a DualShock 3 is determined to be attached, the state machine will advance to the *DEVICE_CONNECTED* state:

```

do{
    USBTasks();

    switch(P3State)
    {
        case DEVICE_NOT_CONNECTED:
            USBTasks();
            if(DisplayDetachOnce == FALSE)
            {
                printf("PS3 Detached\r\n");
                DisplayDetachOnce = TRUE;
            }
            // True if report descriptor
            // parsed with no error
            if(USBHostHIDDeviceDetect(1))
            {
                P3State =
                DEVICE_CONNECTED;
                DisplayConnectOnce = FALSE;
            }
            break;

```

Now that the DualShock 3 is connected to the chipKIT Max32 host, we can send that enable *SIXAXIS* command string. I've placed the *SIXAXIS* command string in a buffer called *ps3EnableCmd*. The USB Explorer 200 trace logged 6 mS of delay between the transmission of the enable *SIXAXIS* command and the rumble/LED control report. Since we went to all of that trouble to craft a millisecond delay function, we'll also place a 6 mS pause for the cause in our code. Just for kicks, I added some rumble to our implementation.

When the DualShock 3 initially connects, both rumble motors will fire. At this point, the DualShock 3 should be ready to start sending reports. So, we will initialize the report request timer before moving on to the next state:

```

0x00, 0x96, 0x7F, 0x96, 0x7F, // rumble
//
control
0x00, 0x00, 0x00, 0x00, 0x02, // LED
//

```

```

Control
0xFF, 0x27, 0x10, 0x00, 0x32, // LED4
0xFF, 0x27, 0x10, 0x00, 0x32, // LED3
0xFF, 0x27, 0x10, 0x00, 0x32, // LED2
0xFF, 0x27, 0x10, 0x00, 0x32, // LED1
0x00, 0x00, 0x00, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x00,
0x00, 0x00, 0x00

```

```

BYTE ps3EnableCmd[] = {0x42,0x0C,0x00,0x00};
case DEVICE_CONNECTED:
    P3State = READY_TO_TX_RX_REPORT;
    if(DisplayConnectOnce == FALSE)
    {
        printf("PS3 Connected\r\n");
        DisplayConnectOnce = TRUE;
        DisplayDetachOnce = FALSE;
        USBHostIssueDeviceRequest( 0x01, 0x21,
        0x09,0x03F4,0x00,0x04,ps3EnableCmd,0,0);
        delays(6);
        USBHostIssueDeviceRequest( 0x01, 0x21,
        0x09,0x201,0x00,0x30,ps3LedCmd,0,0);
    }
    InitializeTimer();
break;

```

The *READY_TO_TX_RX_REPORT* state is a resting

SETUP transaction

Setup request

Name	Value	Dec	Hex	Bin
bmRequestType.Recipient	Interface	1	0x01	00001
bmRequestType.Type	Class	1	0x1	01
bmRequestType.Direction	Host-to-device	0	0x0	0
bRequest	SET_REPORT	9	0x09	00001001
wValue	Feature Report 244	1,012	0x03F4	00000011 11110100
wIndex	Interface 0	0	0x0000	00000000 00000000
wLength	4	4	0x0004	00000000 00000100

■ **SCREENSHOT 7.** This Setup transaction is paving the way to send a total of four payload bytes from the host to the PlayStation DualShock 3 via the interface.

SETUP transaction

Setup request

Name	Value	Dec	Hex	Bin
bmRequestType.Recipient	Interface	1	0x01	00001
bmRequestType.Type	Class	1	0x1	01
bmRequestType.Direction	Host-to-device	0	0x0	0
bRequest	SET_REPORT	9	0x09	00001001
wValue	Output Report 1	513	0x0201	00000010 00000001
wIndex	Interface 0	0	0x0000	00000000 00000000
wLength	48	48	0x0030	00000000 00110000

■ **SCREENSHOT 8.** Our 48 bytes of rumble/LED control data will flow with this Setup transaction.

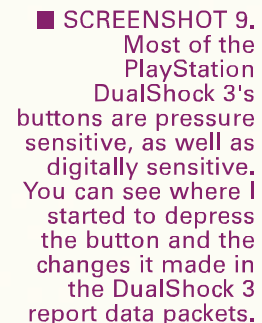
This state is exited under control of the *Timer4* interrupt handler:

The button report generated by the DualShock 3 is 49 bytes long. We use the USB stack's *USBHostHIDRead* function to stuff the incoming 49-byte report data packet into the *ps3ReportBuf*. The *USBHostHIDRead* parameters are defined in this way in their order of appearance:

Once the 49 bytes are deposited into the *ps3ReportBuf* buffer, we send them out along the 115200 bps UART pipe to a terminal emulator. The reports stream very quickly, and you can see changes in the streaming data made by button presses, accelerometer readings, and joystick movement. You can see what I mean by examining **Screenshot 9**:

HOUSTON, WE HAVE CLEARED THE TOWER

We are on our way. Next time, we'll go wireless with our DualShock 3. **NV**





the NIR de-sensitizes the ALS to LED light sources. LED light sources typically have extremely low IR spectral content. If the detector is saturated by light from the LED source it controls, the ALS will enter into a PWM (Pulse Width

Modulation) output, dimming the LED source.

There may be considerable daily variations in weather; clouds, fog, rain, dust, and atmospheric anomalies will impact the on/off triggering window range. For most practical purposes, the point of switching off can be anticipated between dawn and sunrise with the off state maintained throughout the day.

The switching on function can be anticipated to take place between sunset and dusk with the on state maintained throughout the night. In other words, the ALS targets to be on between dusk to dawn (night) and off between sunrise and sunset (day), under normal clear weather conditions.

For the user to determine if the ALS is suitable for their application, three ambient sunlight switching range windows are provided. It can be expected that the on/off function

will take place within these ranges. There is a relationship between visible sunlight and NIR spectral content, with the ALS being most sensitive to the NIR. For general reference, the spectral content of sunlight can be assumed to be 54% in the IR spectrum, 44% in the visible, and 3% in the ultraviolet.

The three ranges listed are based on sunlight detected by the ALS. The mounting position/direction and circuit variability also influence the ranges shown here. The typical hysteresis between triggering points is 60-75 lux.

- 1) Average: On at dusk 110 lux; off at dawn 185 lux.
- 2) Typical: On at dusk >85 lux; off at dawn < 215 lux.
- 3) Worst Case: On at dusk >30 lux; off at dawn < 350 lux.

Continued on page 79



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THE LATEST IN NETWORKING AND WIRELESS TECHNOLOGIES

Making a Modern Radio

A look at how digital techniques have changed and improved analog radios.

Design and construction of a basic analog radio has changed drastically over the years. Radio architecture has evolved from multi-tube designs, to transistors, to integrated circuits, and now, today, to a single chip.

While the rest of the electronics world has gone digital, broadcast radio is still mostly analog. AM, FM, and shortwave (SW) broadcasts are analog, and there are few amongst us that do not listen to one or more of them. That is why there are still hundreds of millions of analog radios still made each year for automobiles, bedside clock radios, portables, high-end stereo systems, and others.

With its enormous population, China is now the largest market for analog radios, but there are still millions sold here in the US.

RADIO BASICS

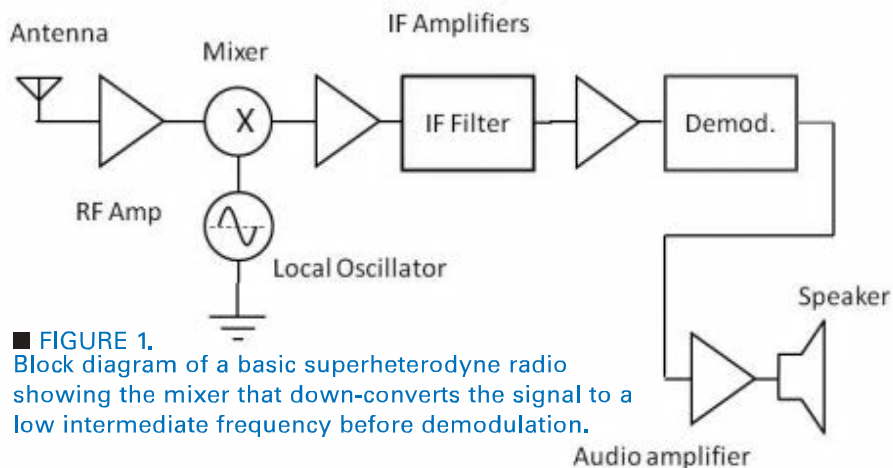
Any radio needs two main things: sensitivity and selectivity. Sensitivity means the radio's ability to receive very small signals and extract the voice, music, or data. Receivers are sensitive because of the gain they provide. Usually, multiple amplifiers are used to allow microvolt level signals to produce full output. The signals are usually amplified before demodulation and after demodulation.

As for selectivity, a radio must be able to be tuned to the desired station, and it must be able to distinguish one signal from another. A radio's tuner is just a variable filter that will let the desired signal through, and reject others nearby in frequency. In crowded urban areas with many stations, this is especially

critical when most broadcast stations are running many kilowatts of power and can easily encroach on one another. Older inductor-capacitor (LC) filters did a fair job, but more recent crystal or ceramic resonator filters are superior. Today, modern digital signal processing (DSP) filters do an even better job.

RADIO CIRCUITS

Most radios evolved from a basic design referred to as a superheterodyne. This type of radio converts the incoming signal down in frequency, usually to a lower frequency called the intermediate frequency (or IF). This is done to simplify tuning and provide good fixed frequency selectivity; refer to **Figure 1**. The basic design includes an RF amplifier after the antenna to



■ **FIGURE 1.** Block diagram of a basic superheterodyne radio showing the mixer that down-converts the signal to a low intermediate frequency before demodulation.

amplify the small signal received. Some cheap receivers omitted this stage. The signal then goes to the mixer stage that does the down conversion to IF. It does this by heterodyning the incoming signal with a higher frequency local oscillator (LO) signal.

The mixer produces the sum and difference signals. The difference signal is usually selected as the IF.

For example, assume the signal is on 98.7 MHz. The mixer combines this with a 109.4 MHz LO signal to generate the sum of 208.1 MHz and the difference of 10.7 MHz. The sum signal is filtered out and the difference is the IF. The 10.7 MHz signal still has all the original modulation on it. That IF signal is then amplified, and selective filters make sure that signals outside the band are rejected.

After some IF amplification and filtering, the signal goes to a detector or demodulator where the

modulation is removed. Therefore, the originally transmitted voice or music is recovered. It is then amplified in an audio amplifier and applied to a speaker or some headphones.

Superhet radios were typically built using five or six tubes or transistors plus loads of discrete resistors, capacitors, and diodes. Integrated circuits came along and reduced the component count somewhat to three or four ICs, but many discretes were still used. The large number of discrete components usually results from the complexity of implementing a multiband (AM/FM/SW) receiver that is also tunable over a wide frequency range. There was no way to simplify this beyond a certain point. The form of construction has kept even the basics of radios complex to manufacture.

THE DIGITAL RADIO

Many units today are what we call software-defined radios (SDR). These radios use a mix of analog and

While the rest of the electronics world has gone digital, broadcast radio is still mostly analog.

digital techniques to allow almost full integration of most radio functions — including tuning — inside a few ICs. The SDR still uses an RF amplifier to boost the signal level and a mixer to down-convert the signal to a lower IF. Then, however, an analog-to-digital converter (ADC) digitizes the signal into binary words that are then sent

Heterodyning

Heterodyning is a radio signal processing technique invented in 1901 by Canadian inventor-engineer Reginald Fessenden, in which new frequencies are created by combining or mixing two frequencies. Heterodyning is useful for frequency shifting signals into a new frequency range, and is also involved in the processes of modulation and demodulation. The two frequencies are combined in a nonlinear signal-processing device such as a vacuum tube, transistor, or diode, usually called a mixer. In the most common application, two signals at frequencies f_1 and f_2 are mixed, creating two new signals, one at the sum $f_1 + f_2$ of the two frequencies, and the other at the difference $f_1 - f_2$. These new frequencies are called heterodynes. Typically only one of the new frequencies is desired, and the other signal is filtered out of the output of the mixer. Heterodynes are closely related to the phenomenon of "beats" in music.

Courtesy Wikipedia



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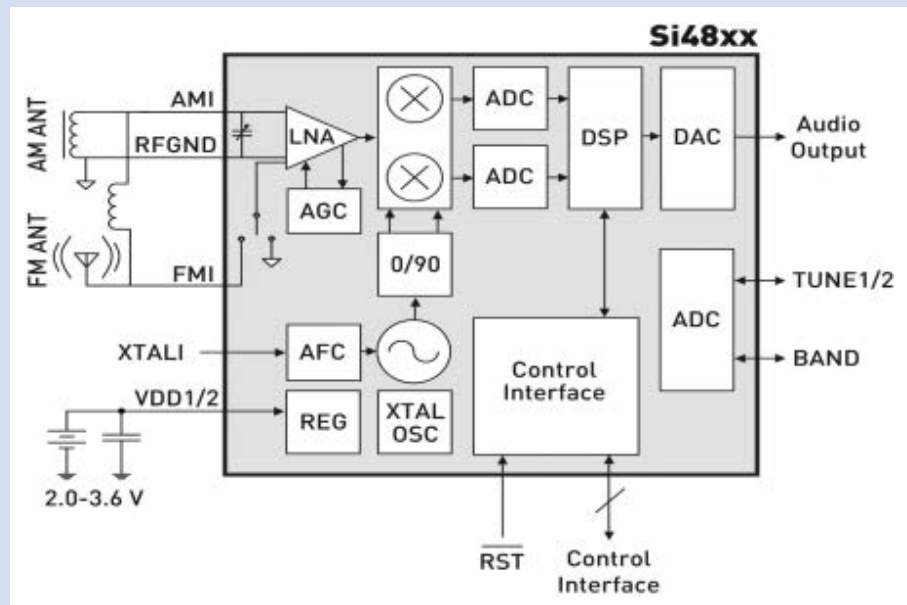
to a block of digital signal processing (DSP) circuitry that performs the filtering for selectivity and the demodulation. The recovered signal in digital form is then sent to a digital-to-analog converter (DAC) where the original analog voice or music is recovered. The analog DAC output is then amplified as usual before going to the speaker.

As for tuning, this is usually accomplished with a frequency synthesizer. This is a mixed-signal (analog and digital) circuit called a phase-locked loop (PLL) that generates the LO signal for the mixers in frequency step increments, rather than a continuously variable frequency.

The SDR architecture greatly reduces the number of components needed to implement the radio. In addition, it also significantly improves the receiver selectivity over any analog design.

A SINGLE CHIP RADIO

There are multiple vendors making what we call single chip radios. A good example are the radios from Silicon Laboratories. They have been making AM/FM and TV tuners using a mixed-signal approach



■ FIGURE 3.
Block diagram of the Si4825 single chip radio.

for several years. One of the more recent is the Si48xx series that puts an entire AM/FM and SW radio in one chip; check out **Figure 2**. It is designed for making auto radios, tabletops, portables, and other form factors. It uses an SDR approach. There are three versions: Si4825/27/36; each has a slightly different tuning option. The Si4836 has stereo outputs while the other two are monaural output.

The block diagram of this single

chip radio is shown in **Figure 3**. The antenna connects to the input with some inductors for impedance matching to the input amplifier. The input RF amplifier is referred to as a low noise amplifier (LNA) because it amplifies without adding any significant amount of noise to the signal. The amplified signal is sent to two mixers. The local oscillator is a synthesizer that generates two LO sine waves; one shifted 90 degrees from the other. The mixers get the phase shifted signals at the same frequency and then produce two low frequency IF signals shifted 90 degrees from one another. These are called the I and Q signals, meaning in-phase and quadrature (90 degree) phase. The IF is low, in the 100 kHz range. The analog signals are then digitized by the ADCs producing two quadrature bit streams to the DSP. The DSP circuits implement mathematical algorithms to do the IF filtering and demodulation. The DSP output then is a digital form of the original analog modulation that is then sent to the DAC for conversion back to analog for amplification. Another IC power amplifier drives the speaker.

Some of the other circuits are an automatic gain control (AGC) that helps keep the signal level to the

■ FIGURE 2.
Silicon Labs Si48xx series single chip radios cover worldwide AM, FM, and shortwave bands to make any type of consumer radio product.





■ **FIGURE 4.**
A popular analog-tuned, digital display (ATDD) portable AM/FM/SW radio from C Crane Company.

mixers as constant as possible, despite signal strength variations. There is also an automatic frequency control (AFC) circuit that keeps the local oscillator on frequency in spite of temperature or other undesired variations. An internal crystal oscillator is used as a reference for the frequency synthesized LO.

The block called control circuitry is used to implement the external frequency display and the tuning. The tuning is handled by an external potentiometer or step attenuator connected to a DC voltage. The varying DC voltage is applied to the TUNE1/2 pin, and converted into a digital number by the ADC and used to set the LO synthesizer on frequency. The whole chip is housed in a 16-pin small outline IC. Power comes from a DC source of 2.0 to 3.6 volts. This is regulated to a constant value by the on-chip regulator.

As for antennas, a standard ferrite core inductor is used for the AM antenna, and the FM antenna is a small collapsible whip. The SW section uses the FM antenna.

The chip radio tunes the full worldwide AM and FM bands. AM range is 504 to 1750 kHz; FM covers 64 to 109 MHz; and SW covers 2.3 to 28.5 MHz.

TUNING AND DISPLAY OPTIONS

Modern radios come in three basic formats: analog-tuned, analog display (ATAD); analog-tuned, digital display (ATDD); and digital-tuned digital display (DTDD). The ATAD radios are the old familiar type using a knob or wheel for tuning, and a circular or linear dial to display the frequency. The ATDD mode uses a knob or wheel for tuning and a digital (LCD or LED) numerical frequency display.

The DTDD radios usually use pushbuttons for channel selection tuning and an LCD or LED display. Humans still seem to prefer a knob for tuning, so the wheel tuned ATDD form is still the most popular. **Figure 4** shows an example of this form, although it does not use the Silicon Lab chips. The tuning circuitry inside the Si48xx chips implement the ATDD mode. The radio works with an external embedded microcontroller for the display. An external pot with knob or a detent-type click wheel is used to set the frequency.

For more details on the Silicon Labs chips, see www.silabs.com. **NV**

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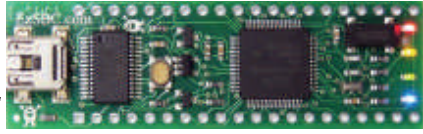


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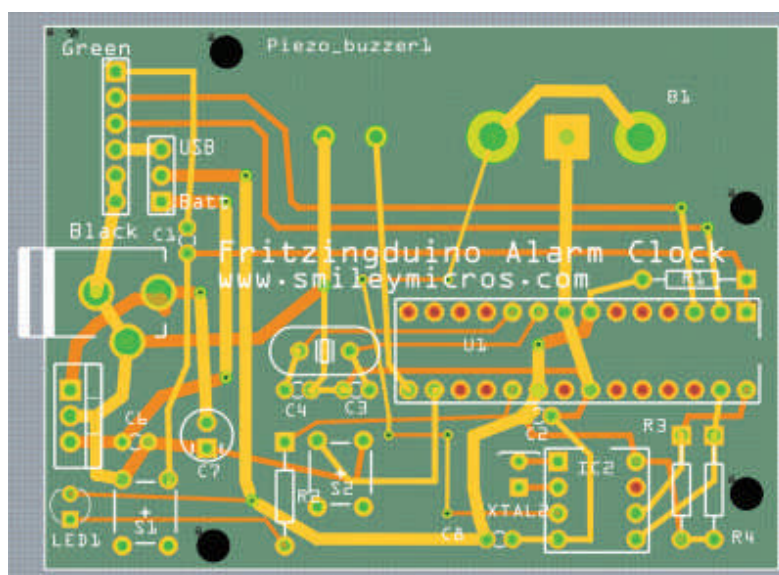
SMILEY'S

#59 WORKSHOP

C PROGRAMMING - HARDWARE - PROJECTS

FRITZINGDUINO - PART 2

Last month, we continued learning about Arduino Fritzing prototype to production. We finished the alarm clock software by learning to make it more accurate. Then, we learned to roll our own Arduino using Fritzing by designing the Fritzingduino. To be a 'real' clone, the Arduino requires a bootloader. So, this month we will further amass knowledge about how to become more independent in our development by adding a bootloader ourselves using tools provided by the Arduino IDE. Following that, we will learn to make ourselves even *more* independent by using Fritzing to combine an Arduino shield design with the Fritzingduino into a single printed circuit board (PCB) design like the alarm clock shown in Figure 1.



■ FIGURE 1. Fritzingduino alarm clock PCB layout.

CHICKEN OR EGG

One of our goals with the Fritzingduino is to save money. We can have an Arduino compliant system without having to purchase an Arduino and a shield since we can now design our own. To do this, we need an ATmega328 with an Arduino compliant bootloader on it.

You can get a preprogrammed ATmega328 from either AdaFruit or SparkFun for about \$6 which is a good deal, all things considered. You can also get raw ATmega328 chips for about \$2 and program them yourself.

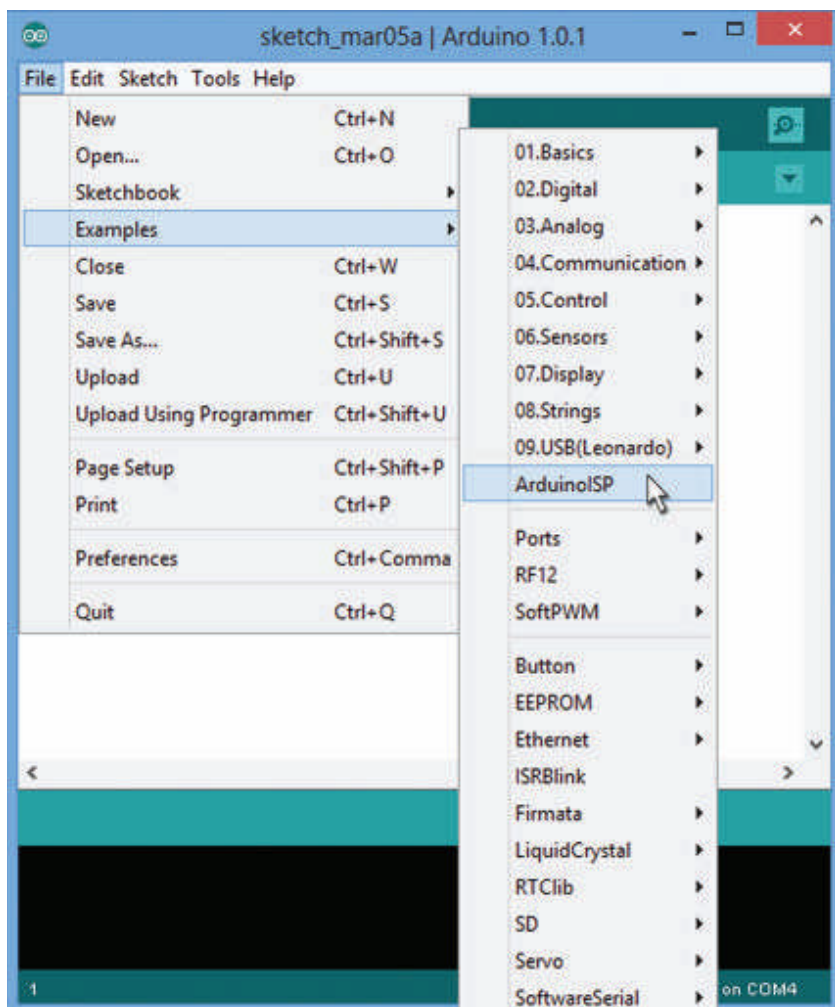
If you only need a couple of ATmega328s with bootloaders, then buying them preprogrammed makes sense. If you're going to be doing a bunch of Fritzingduino style projects, you'll want to have your own tools for burning the bootloaders on to the chips.

There are some tools for this that

you can purchase, like the Atmel STK500, the Atmel AVRISP, or the Atmel Dragon that you can get from the Atmel web store for \$79, \$49, and \$34, respectively. These are really great prices by the way, but I think you can safely skip the Atmel tools and just acquire a regular Arduino for this project for a couple of reasons.

First and foremost, having a known good Arduino system can radically reduce your debugging efforts as you build Fritzingduino systems. If something works on the 'real' Arduino and doesn't work on your Fritzingduino, it is probably the Fritzingduino's fault.

Second, you can use an Arduino to burn the bootloader into your ATmega328. The store-bought Arduino will pay for itself doing this if you do more than a couple of roll-your-own Arduino projects. So, let's learn how to use an Arduino to program a raw ATmega.



■ FIGURE 2. ArduinoISP in IDE.

ARDUINOISP

The ArduinoISP program was written by Randall Bohn and is included in the Arduino IDE under Examples as shown in **Figure 2**. The ATmega328 can be programmed using the ISP (In-System Programmer) feature that allows you to use the SPI (Serial Peripheral Interface) bus to load programs into Flash memory. SPI uses the SS, MOSI, MISO, and SCK lines shown below. Fortunately, the ISP and SPI 'just work,' so we don't need to discuss them in detail here.

Before we learn to use it, let's first look at how to build it.

BUILD AN ARDUINOISP BOARD ON AN ARDUINO PROTO SHIELD

The ArduinoISP code is wired to use the Arduino pins as follows:

- 7 - Programming LED
- 8 - Error LED
- 9 - Heartbeat LED
- 10 - SS
- 11 - MOSI
- 12 - MISO
- 13 - SCK

The ArduinoISP program uses three LEDs to help you see what is going on. These LEDs aren't absolutely necessary to make this project work, but I included them in case you want to watch the action.

Since we are going to build a proto shield board that uses the ArduinoISP, we will need to design our ISP programmer to use these Arduino pins with components on the proto shield. To do that, we need to remember that the Arduino pins are not the same as the ATmega328 pins

When you are wiring an Arduino to an ATmega328, it is easy to get confused. **Figure 3** shows an ATmega328 with both the native IC pin numbers and the associated Arduino pin numbers. This diagram may help when you are wiring this project, as will the schematic in **Figure 4**.

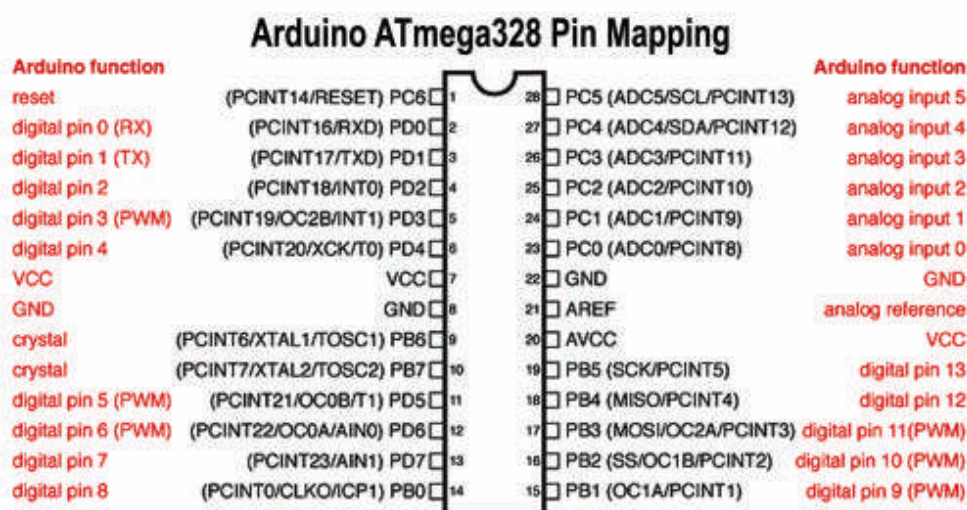


FIGURE 3.
Arduino
ATmega328
pin mapping.

Digital Pins 11, 12 & 13 are used by the ICSP header for MISO, MOSI, SCK connections (Atmega168 pins 17, 18 & 19). Avoid low-impedance loads on these pins when using the ICSP header.

Sch. Part	Description	SparkFun Part #
Part1	Arduino	DEV-11021
U1	ATmega328P	COM-09061
Q1	Crystal 16 MHz	COM-00536
S1	Mini pushbutton	COM-00097
C1,C2	22 pF capacitor	COM-08571
R1,R1,R3,	1K ohm resistor	COM-08980
LED1	Red LED	COM-00533
LED2	Yellow LED	COM-00533
LED3	Green LED	COM-00533

Table 1. ArduinoISP on a proto shield — Bill of Materials.

You can use this information to wire up an Arduino proto shield breadboard as shown in the Fritzing view in **Figure 5**. As mentioned, the Fritzing schematic is shown in **Figure 4** and the Bill of Materials for this design is listed in **Table 1**. In **Figure 6**, we have a photograph as proof that I really did build this thing on a proto shield breadboard. And, yes, it works. Finally, **Figure 7** shows the components ported from the breadboard to the proto shield PCB for a more robust system — something you'll need if you use the ArduinoISP a lot.

You should be able to build this circuit following the schematic and the breadboard views. One thing to note is that ICs are shipped with their pins spread wider than the 0.3 spacing of the socket width. This is because they are usually inserted with a tool that squeezes them to the correct width before inserting them in a socket. When you

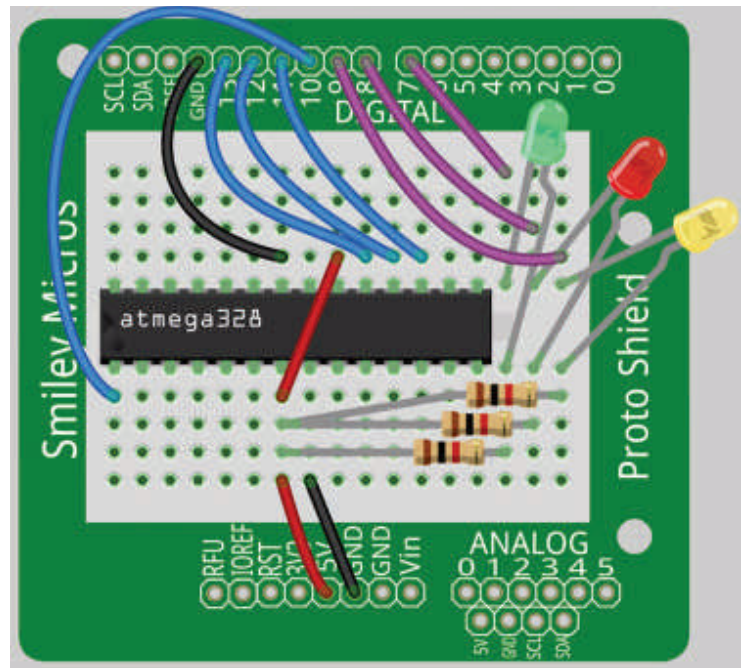


FIGURE 5. Fritzing ArduinoISP with proto shield.

go to put the ATmega328 in the breadboard, you'll find the pins flare out too much. So, very carefully bend them in a smidgen by holding the IC and pushing the pins sideways against a table. This is a craft, not a science. So, experiment carefully. You don't want to bend the pins more than once since they will break.

You can use the regular Arduino proto shield kit available from the *Nuts & Volts* web store as the basis for this project, but you might also consider getting the

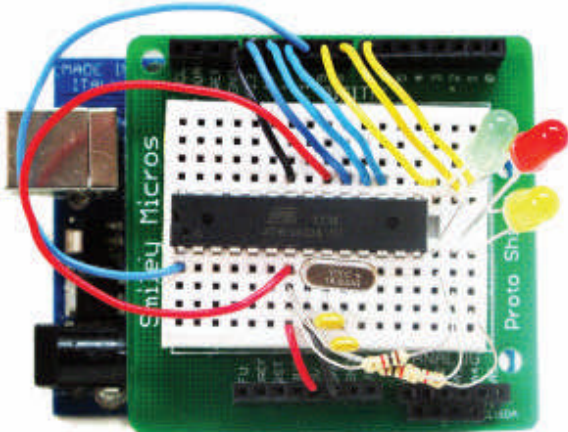


FIGURE 6. ArduinoISP on proto shield breadboard.

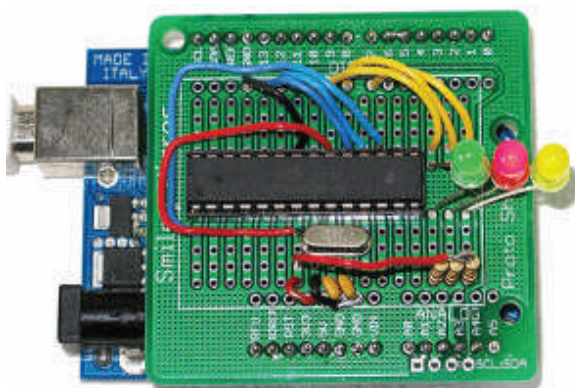


FIGURE 7. ArudinoISP on proto shield PCB.

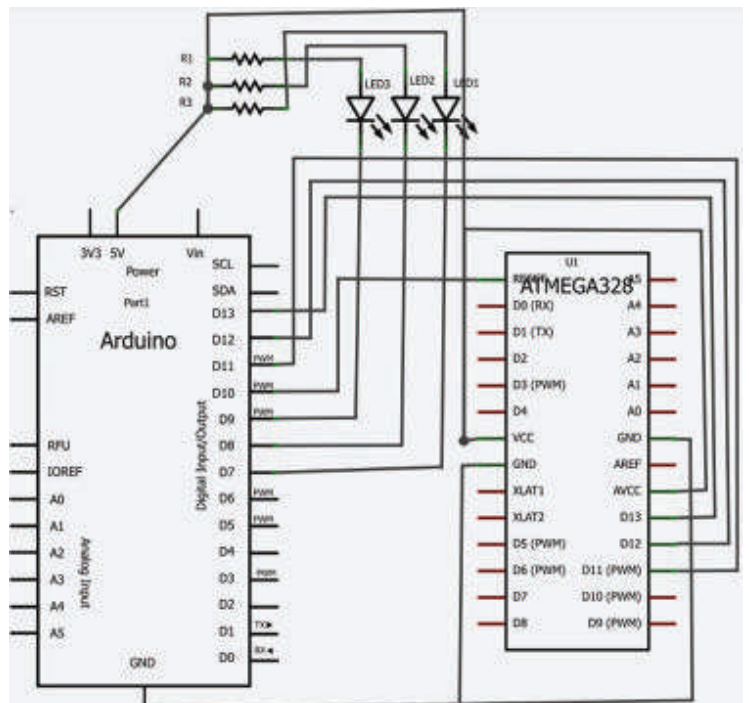
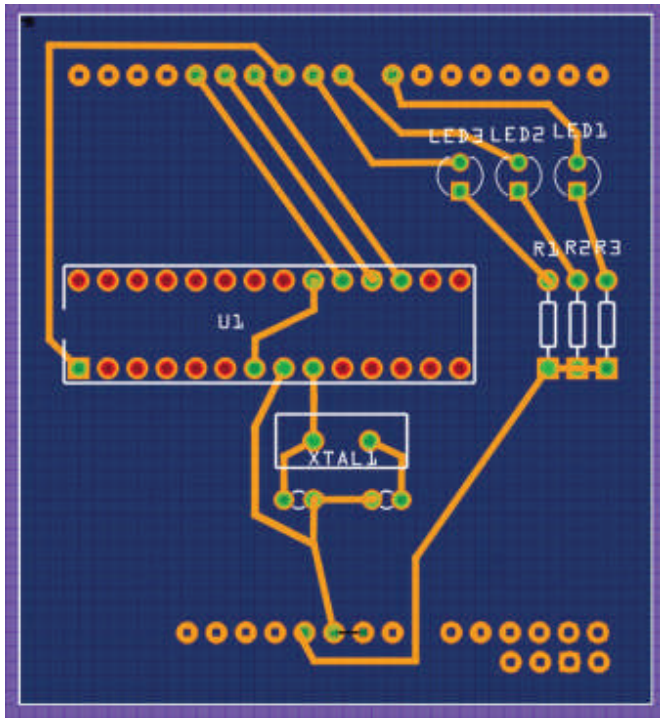


FIGURE 4. ArduinoISP schematic.



■ FIGURE 8. ArduinoISP Fritzing PCB view.

Arduino Extra kit with three additional PCBs. This allows you to spawn three PCBs (as in **Figure 7**) while still having your breadboard proto shield to do future development. Also note that while a single ATmega328P is listed in the BOM, you'll want to get as many ATmega328Ps as you think you'll need for your future Fritzingduino projects.

DESIGN YOUR OWN ARDUINOISP PCB WITH FRITZING

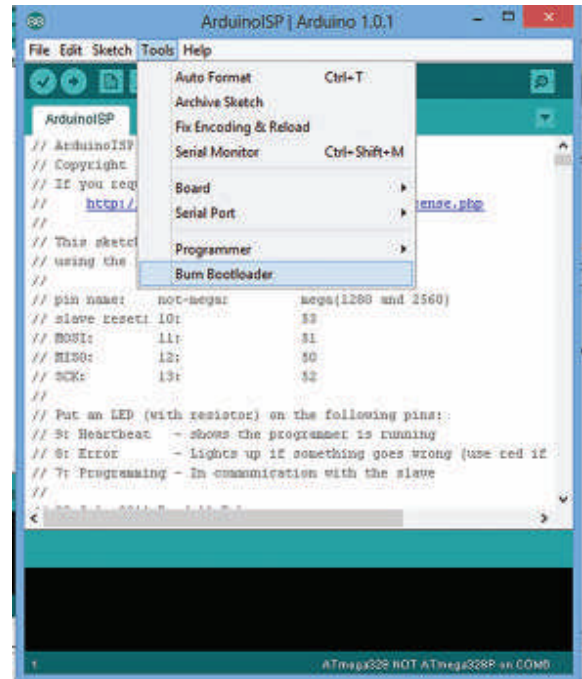
It is simple enough to generate the PCB files for the ArduinoISP design in Fritzing (shown in **Figure 8**). I decided not to get a board fabricated for this design since it is simple enough to wire this up on a proto shield PCB as shown back in **Figure 7**. Plus, I only need one of them.

USING THE ARDUINOISP

Using the ArduinoISP is a little tricky because we have to keep in mind that we are using the Arduino IDE to upload two separate programs. First, we'll upload the ArduinoISP code to the Arduino, then we'll use the Arduino with the ArduinoISP application in it to upload the bootloader to the raw ATmega328 using the ISP wires in our hardware design. Let me repeat. First, upload the ArduinoISP application from the PC to the Arduino. Then, use that application to upload the bootloader from the Arduino to the ATmega328 on the shield. Two steps — clear?

Uploading the ArduinoISP Example

Recall that **Figure 2** shows the Arduino IDE with the



■ FIGURE 9. FTDI USB to TTL.

File/Examples/ArduinoISP highlighted. Click on that file and it will appear in the text editor. You load this to the Arduino like you do any other program. Make sure you've selected your board, and then click on the Upload button. Now it gets tricky.

Uploading the Bootloader to the Raw ATmega328

If you are loading a bootloader to an ATmega328P, you open the Tools/Boards menu item and select an appropriate board such as the 'Arduino Duemilanove with ATmega328.' [Note that you aren't actually using an Arduino Duemilanove — you are just telling that to the IDE so that it will use the bootloader for the ATmega328.] Next — also in the Tools menu — you click on the 'Burn Bootloader' menu item as shown in **Figure 9**. It may take a minute or two for the bootloader to be uploaded. FYI, the OptiBoot bootloader is the one being uploaded it.

Can it be that simple?

Well, let's hope so. Unfortunately for me, I had a bunch of ATmega328s NOT ATmega328Ps, and although the menu items and tutorials for the ArduinoISP say Atmega328, they really mean Atmega328P. In order to use the ATmega328 with no P, you've got to work a bit harder. You must add the ATmega328 to the *arduino.conf* file located in *...Arduino-x.x/hardware/tools/avr/etc/arduino.conf*. You must also add it to the *boards.txt* file located at: *...arduino-x.x/hardware/Arduino/boards.txt*.

Of course, the *arduino-x.x* is whatever your version of the Arduino IDE is; in my case, it is *arduino-1.01* (at the moment). You will add the ATmega328 to these two files by copying blocks of text from a file I've provided and

then pasting the blocks to the indicated files.

Open these files in a text editor such as Programmer's Notepad. You will copy a block of code to each of these files and then save them back to their original location. Just to be safe, make a copy of the originals of both files before changing them in case you mess something up.

You can get the two blocks of text from a zip file that you can find at the article link. The file name is 'ArduinoISP Atmega328 files.zip' and it has two text files in it: 'Add to Arduino Conf File.txt' and 'Add to boards dot text.txt.' Open these in your text editor and do like the name says — add them to the indicated files *arduino.conf* and *boards.txt*.

One final caveat: This design works for the Atmega328. It may work for other 28-pin ATmegs, but you are going to have to figure that out yourself. There is a bit of Internet chatter on how to modify the original ArduinoISP design and associated files to do this, but since I'm only interested in rolling my own Arduino with the Fritzingduino concept, I'm not interested in pursuing other ATmegs at the moment.

ARDUINO + SHIELD = SINGLE PCB

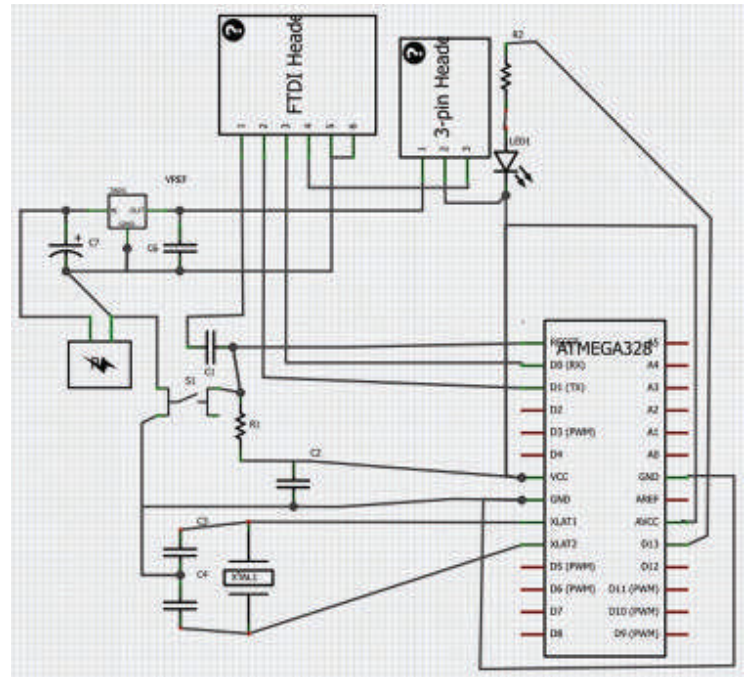
We've discussed the economies of rolling our own Arduino with the Fritzingduino, and we can extend those economies by adding our shield designs to our Fritzingduino so that we have a single PCB and don't need those male/female shield connectors. For example, we've learned to design an alarm clock for an Arduino shield. We could add that shield design to our Fritzingduino and have the whole thing on a single PCB, thus saving us the cost of the Arduino, the shield, and all those headers.

Since we want to get this all on a single PCB, we don't need standard Arduino headers to accommodate a shield — there is no shield. First, we want to create a Fritzingduino base design that has no headers. **Figure 10** shows a schematic view for such a design; **Figure 11** shows the PCB view.

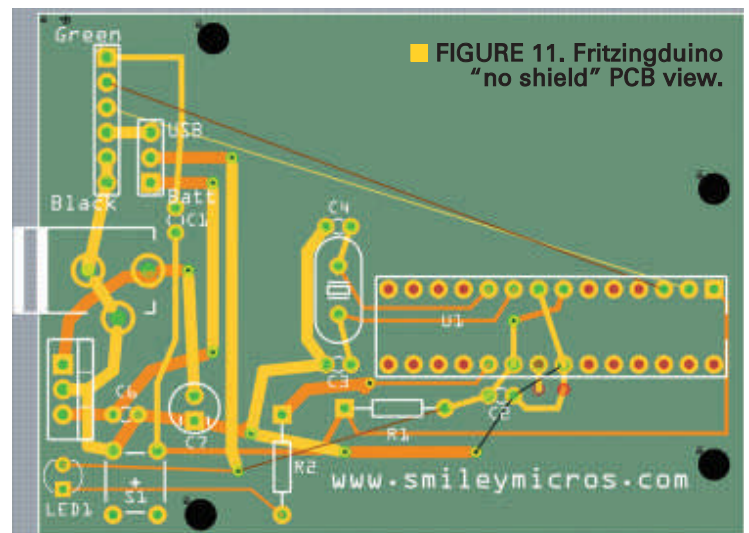
We call this the *Fritzingduino_No_Shield* and as you can see, it isn't much use as-is. However, it provides the minimal Arduino clone circuit for our 'Arduino + Shield = Single PCB' equation, so let's save it as *Fritzingduino_No_Shield.fzz* so that we can reuse it in the '+ Shield' designs. You'll find this project at the article link.

FRITZINGDUINO + ALARM CLOCK SHIELD = FRAC

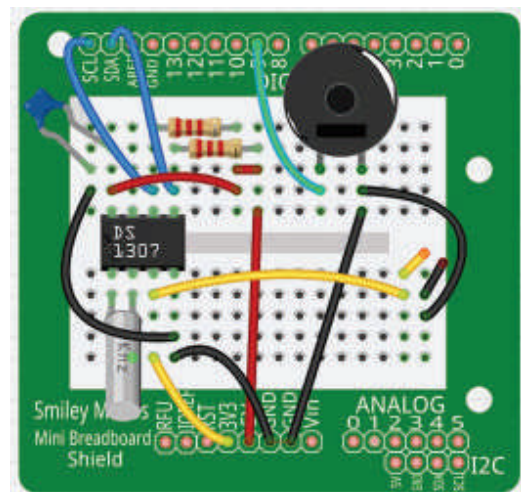
Battlestar Galactica fans will like our new acronym: FrAC. You'll want to open the *Fritzingduino_No_Shield.fzz* file and then save it as *FrAC.fzz*. Next, open the *Alarm Clock.fzz* file (at the article link) shown in **Figure 12**.



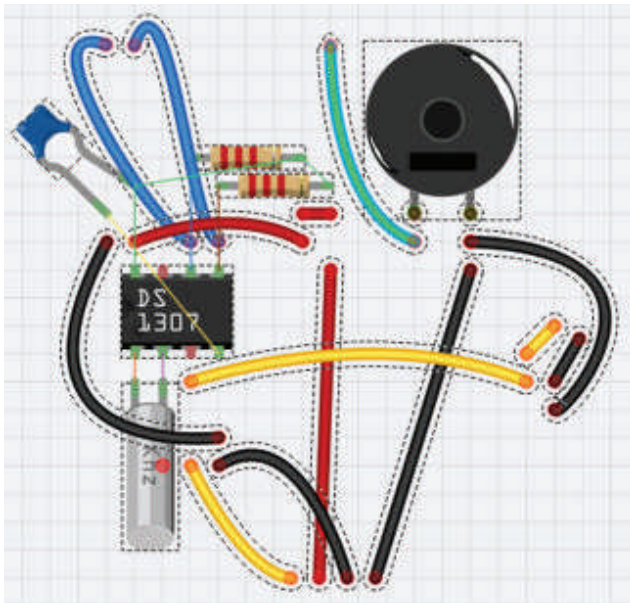
■ FIGURE 10. Fritzingduino "no shield" schematic view.



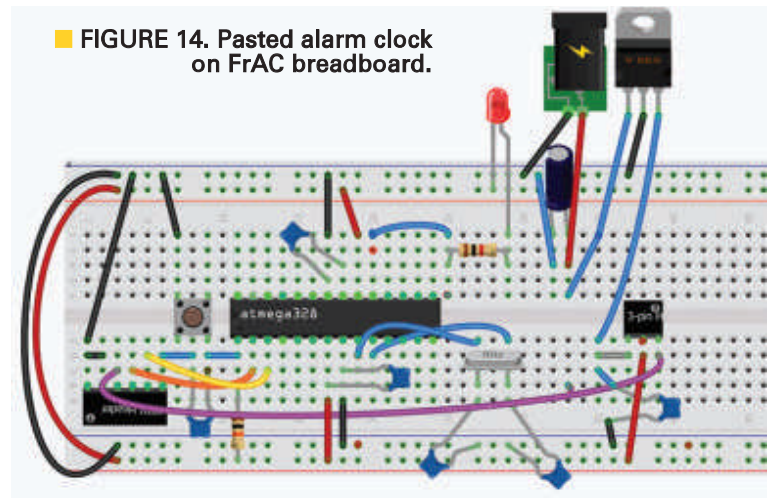
■ FIGURE 11. Fritzingduino "no shield" PCB view.



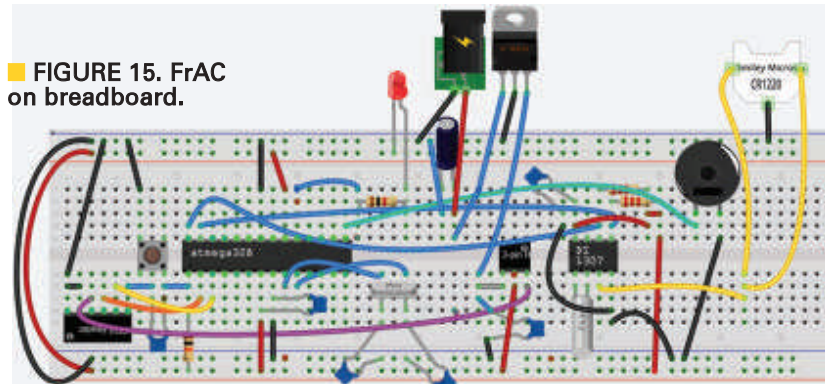
■ FIGURE 12. Alarm clock on proto shield.



■ FIGURE 13. Alarm clock parts copied and ready to paste.



■ FIGURE 14. Pasted alarm clock on FrAC breadboard.



■ FIGURE 15. FrAC on breadboard.

Delete the proto shield and mini breadboard, which will leave you with the components shown in **Figure 13**. Now, do a block copy of these components and open the Fritzingduino project. Paste the components on the

breadboard as shown in **Figure 14**. You'll need to delete and/or move some of the wires, then add the CR1220 battery component as shown in **Figure 15**. Note the following when wiring this design:

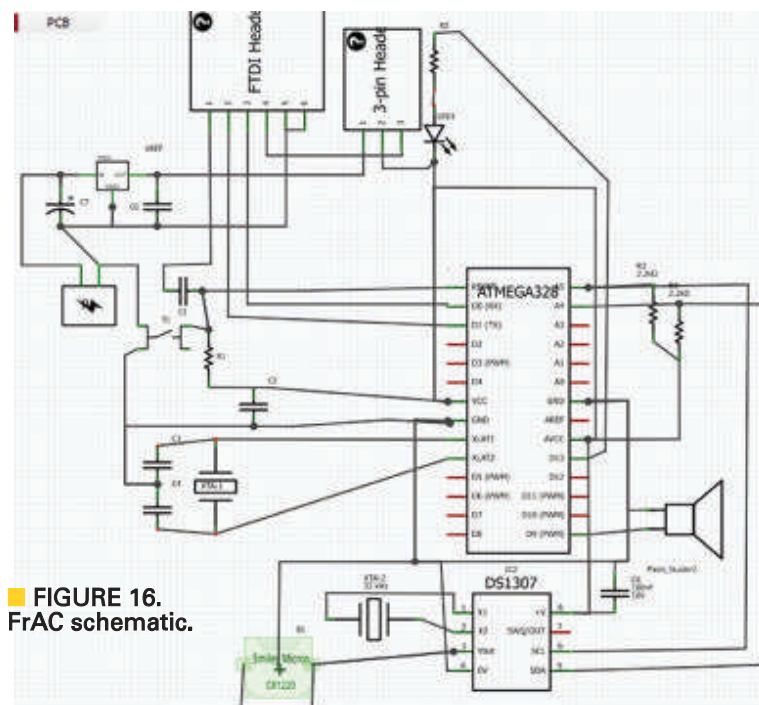
- Digital pin 9 is PB1 pin 15 on the ATmega328 IC
- SCL is PC5 pin 28
- SDA is PC4 pin 27

You'll get a schematic shown in **Figure 16** (of course, you'll need to move the connections around a bit to get this exact image). The resulting breadboard view is shown back in **Figure 1**. Now you have combined a minimal Arduino clone with an alarm clock design on a single PCB. Plus, you've developed some major prototyping skills in the process.

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■ FIGURE 16. FrAC schematic.

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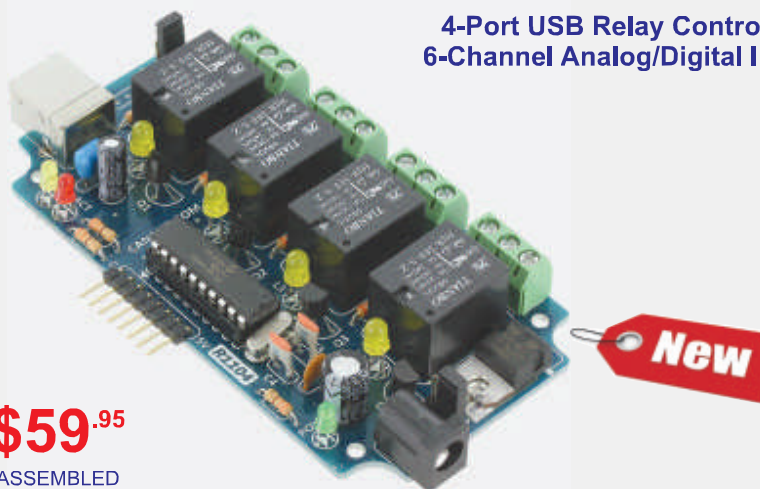


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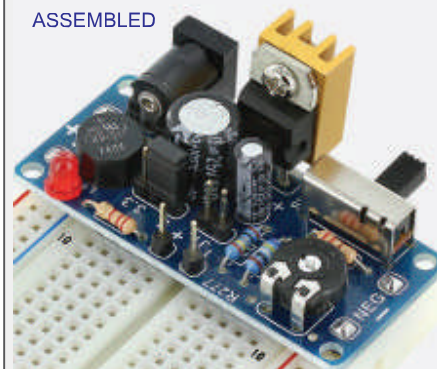
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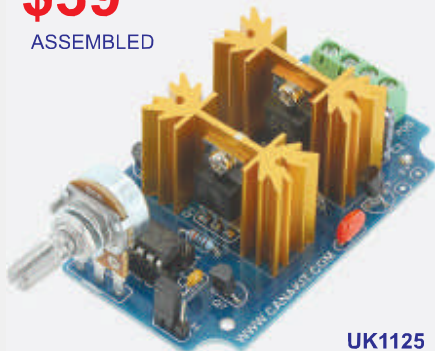


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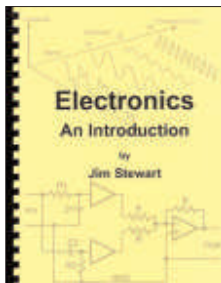


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by Jim Stewart

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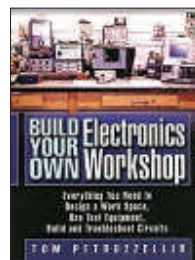
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by Chuck Hellebuyck

If you wanted to learn how to program microcontrollers, then you've found the right book! Microchip PIC microcontrollers are being designed into electronics throughout the world and none is more popular than the eight-pin version. Now the home hobbyist can create projects with these little microcontrollers using a low cost development tool called the CHIPAXE system and the Basic software language. Chuck Hellebuyck introduces how to use this development setup to build useful projects with an eight-pin PIC12F683 microcontroller. **\$14.95**



Master and Command C for PIC MCUs

by Fred Eady

Master and Command C for PIC MCU, Volume 1 aims to help readers get the most out of the Custom Computer Services C compiler for PIC microcontrollers.

The author describes some basic compiler operations that will help programmers particularly those new to the craft create solid code that lends itself to easy debugging and testing. As Eady notes in his preface, a single built-in CCS compiler call (output_bit) can serve as a basic aid to let programmers know about the "health" of their PIC code.

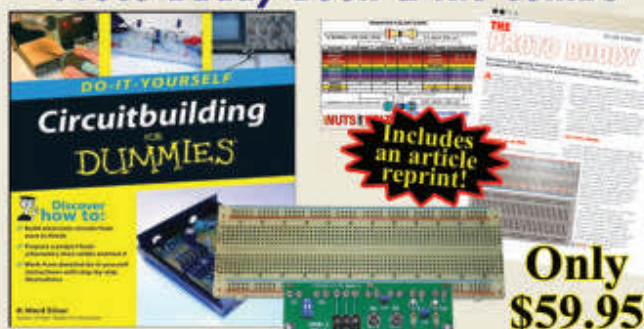
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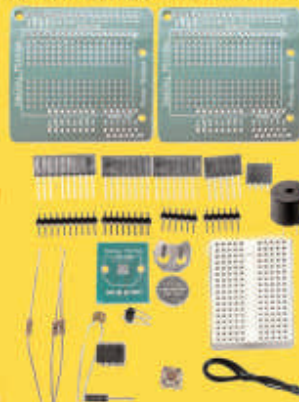
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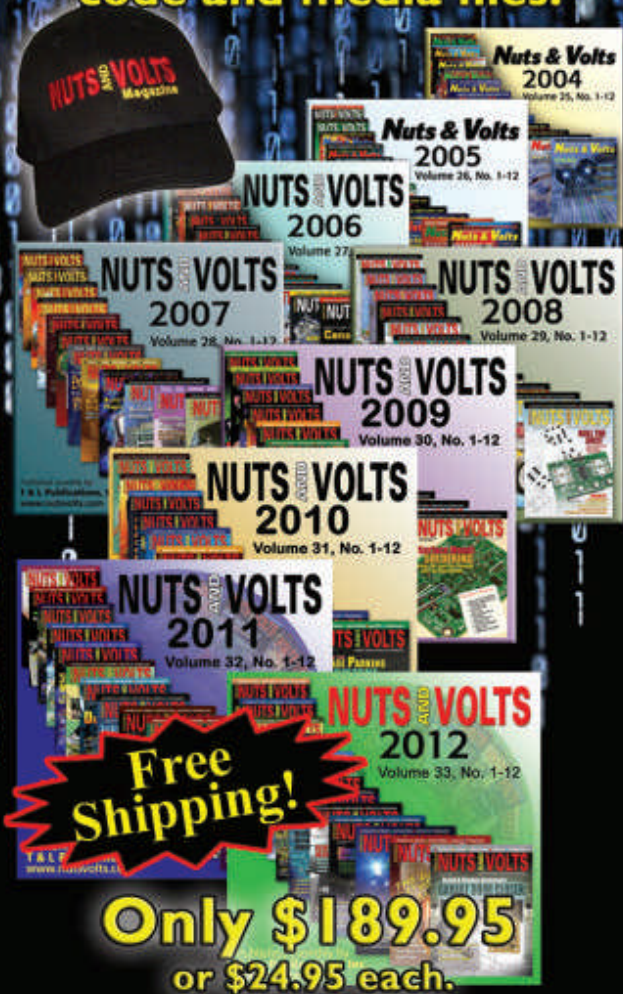


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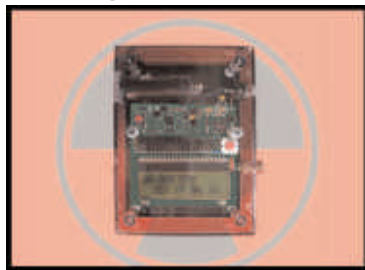
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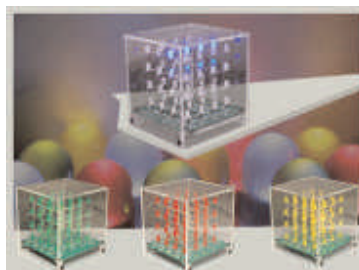


This kit is a great project for high school and university students. The unit detects and displays levels of radiation, and can detect and display dosage levels as low as one micro-roentgen/hr. The LND712 tube in our kit is capable of measuring alpha, beta, and gamma particles.

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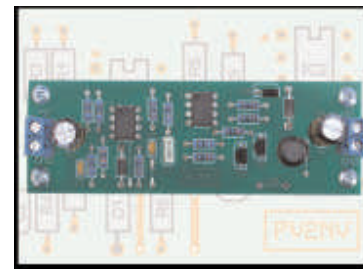


This kit shows you how to build a really cool 3D cube with a 4 x 4 x 4 monochromatic LED matrix which has a total of 64 LEDs. The preprogrammed microcontroller that includes 29 patterns that will automatically play with a runtime of approximately 6-1/2 minutes. Colors available: Green, Red, Yellow & Blue

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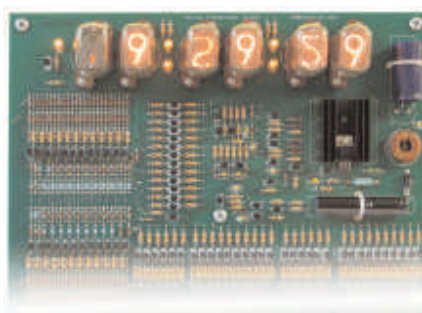


If you need +12V and -12V, but all that's available is +12V, then this project is for you. The inverted DC-DC converter gives you -V out when you put +V in, and works over a range of voltages without adjustment. It's an easy to build voltage mirror that can supply over 100 mA without a significant drop in voltage.

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Neon Transistor Clock Kit



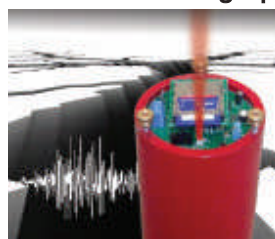
Add HIGH VOLTAGE to your clock!
 This is a Nixie Tube display version of the Transistor Clock. It uses only discrete components — no integrated circuits.

For more info, see the April 2012 issue.

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Seismograph Kit



As seen in the May 2012 issue.

Now you can record your own shaking, rattling, and rolling.

The Poor Man's Seismograph is a great project /device to record any movement in an area where you normally shouldn't have any. The kit includes everything needed to build the seismograph. All you need is your PC, SD card, and to download the free software to view the seismic event graph.

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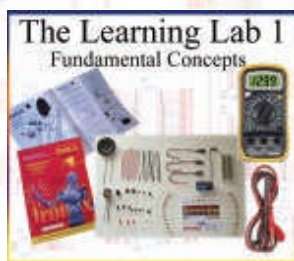
As seen on the April 2007 cover.

This unique DIY construction project blends electronics technology with carefully planned handcraftsmanship. This clever trick has the observer remove one of six pawns while you are out of the room and upon re-entering you indicate the missing pawn without ever opening the box.

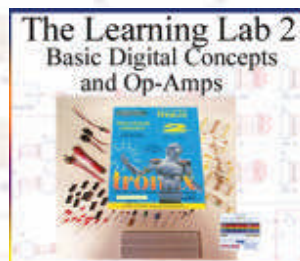
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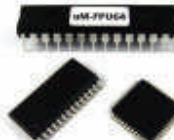
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>>> QUESTIONS

Low Power IR Remote

I would like to make an IR remote control to be used in nursing homes to activate alarm equipment. *Specifications are:* Receiver: nine volt, VERY LOW power consumption; Transmitter: handheld, battery powered, three volt (lithium?), 2-5 meter range.

#6131 **Claes Kamborn**
via email

Project Building

What's the best way to cut a one inch hole in a metal or plastic project box? What about a square hole?

#6132 **George Powelson**
Ogden, UT

Drive By Wire

I want to build a 'drive by wire' system for a project that I have been working on. I have enough electronics knowledge that I feel I could build the circuit by hand if I could get help on the circuit diagram and parts needed.

I want to operate the throttle on a 14 HP engine via a servo with the gas pedal hooked to a potentiometer, so that when the 'gas' pedal is pushed, it will open the throttle on the engine and vice versa (close when 'gas' pedal is released). The servo would need to return to the same position as the pedal potentiometer.

The circuit needs to run on a 10-15 volt DC automotive voltage, and be turned on and off with the ignition switch. This would have to be bullet proof because of the vibration caused by the engine and terrain. The servo

must be able to hold the throttle position for as long as the driver has his foot on the gas pedal in any position, and then return to the zero position when the foot pedal is released (return to the zero position). Can someone help me accomplish this?

#6133 **Victor Dunford**
via email

Camcorder To Security Cam

I have many old MiniDV or Hi-8 camcorders that still work very well as far as the camera and monitor, not so much for the recorder portion.

Has anyone thought of re-purposing these to just use the camera portion for a security/process monitor camera? Some old camcorders have superb resolution, a very low lux rating for color, and great remote control functions for focus, iris, and zoom. I would need to disable the time-out function for the recorder, which saves the heads if not running for a while by shutting down. Saves a lot over getting a PTZ camera — if you need the P & T, a small servo could do that function.

Anyone tried this? Please post your experience.

#6134 **James Joyce**
via email

Salvaging Parts

Since money for hobbies is hard to come by these days, is it worth trying to salvage parts from old electronic equipment to build new projects? What kind of equipment has the most usable parts — old TVs, computers, stereos? How far do component values

deteriorate over time to become unreliable? Any advice out there?

#6135 **Clint Stevens**
Houston, TX

Cell Phone Battery Cable

How can I make a cable so that I could use a nine volt battery for my cell phone? Would a large six volt lantern battery work? Are there any electronics needed?

#6136 **George Powelson**
Ogden, UT

Excerpted from #7121

Modify Scott 340A Tube Receiver

I live very close to a huge water tank that affects stereo reception. I would like to connect a scope to measure FM multipath distortion. Does anyone know exactly how to do this?

Answer

You need an X-Y oscilloscope — preferably with response down to DC. Connect the horizontal X input to the output from the audio detector (still monophonic, not yet demultiplexed) and connect the vertical Y input to the AGC (automatic gain control) signal.

Follow-up To #7121

I switched my tube system to separate units now using a Scott 350B. I need to check multipath distortion as in Tech Forum #7121, but wonder what bandwidth I need for a scope. I assume 100 MHz, but would a lower bandwidth (less costly) scope work okay? Would I hook it up as noted in #7121?

#6137 **Nick Oshana**
Bristol, CT

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or via the online form at www.nutsvolts.com/tech-forum

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Traditionally, photocell switches are positioned facing north to equalize between the sunrise in the east and the sunset in the west for applications in the northern hemisphere. The wide angle lens of the ALS is used to moderate or reduce the dependence on being mounted north.

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MODULES OFFER SIMPLE SOLUTION FOR GPS APPLICATIONS

The new R4 and F4 Series GPS modules from Linx make it cost-effective to add GPS capability to new and existing applications through a simple serial interface.

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The R4 Series offers an operating voltage range from 3.0V to 3.6V, while providing a typical 0.43 mA hibernate mode for extending battery life in low power applications.

The F4 Series GPS module is ideal for applications where low power is required. With an operating voltage of 1.8V and low power modes such as Trickle-Power and Push-to-Fix, the F4 module will hibernate with current draw as low as 20 uA.

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To aid rapid development, the R4 and F4 Series GPS modules are available as part of a master development system. The system comes with a development board for benchmarking and prototyping,



an evaluation module containing the GPS module and surrounding components, an onboard display for mobile evaluation, and a USB interface for custom application design.

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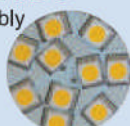
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CAT# LED-610WW



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EXPERIMENTER'S DELIGHT/ CHARGER BOARD

Originally a conditioning charger for a 14.4V 2600 mAh LI-ION/LI-POLYMER battery. We're working on a hook-up diagram. However, in the mean time, this circuit board has a 100uH, 4.3A inductor, CTX100-2-52M, that is well worth the price of the board. With a little effort you can remove the inductor, 3 sets of header connectors, a MOSFET, two voltage regulators, two TO-220 aluminum heatsinks, three 330 uF 35v radial electrolytic capacitors.



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Metal-armored, encapsulated thermal sensor. NTC (resistance drops as temperature increases) thermistor, approximately 50K Ohms @ room temperature. Metal probe is 23.5mm long x 4mm diameter (widest part) x 2.5mm dia. (top third). 7mm diameter (brass?) collar surrounds middle of probe. 6" pigtail leads. Removed from equipment in good condition.



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Standard size analog servo motor. 49oz-in torque @ 6Vdc. 0.19 sec/60° @ 6V. 6.5" leads with JR connector.



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- ✓ Dual LED bar graph audio level meters!
- ✓ Automatic adjustable microphone ducking!
- ✓ Easy to build through-hole design!



This professional synthesized transmitter is adjustable directly from the front panel with a large LED digital readout of the operating frequency. Just enter the setup mode and set your frequency. Once selected and locked you are assured of a rock stable carrier with zero drift. The power output is continuously adjustable throughout the power range of the model selected. In addition, a new layer of anti-static protection for the final RF amplifier stage and audio inputs has been added to protect you from sudden static and power surges.

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The FM100B series includes an attractive metal case, whip antenna and built in 110/220VAC power supply. A BNC connector is also provided for an external antenna. Check out our Tru-Match FM antenna kit, for the perfect mate to the FM100B transmitter.

We also offer a high power kit as well as an export-only assembled version that provides a variable RF output power up to 1 watt. The 1 watt unit must utilize an external antenna properly matched to the operating frequency to maintain a proper VSWR to protect the transmitter. (Note: The FM100B and FM100BEX are do-it-yourself learning kits that you assemble. The end user is responsible for complying with all FCC rules & regulations within the US or any regulations of their respective governing body. The FM100BWT is for export use and can only be shipped to locations outside the continental US, valid APO/FPO addresses or valid customs brokers for documented end delivery outside the continental US).

FM100B Super-Pro FM Stereo Radio Station Kit, 5uW to 25mW Output \$269.95
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Record and playback up to 8 minutes of messages from this little board! Built-in condenser mic plus line input, line & speaker outputs. Adjustable sample rate for recording quality. 4-switch operation that can be remote controlled! Runs on 9-12VDC at 500mA.

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Unlike most Nixie clocks, the clocks also display the date in DD.MM.YY, MM.DD.YY, or YY.MM.DD format, which can be programmed to display for a few seconds at the end of each minute either as a static display, display wise, the clocks feature a programmable night mode with dim or blank display, a programmable master blank tube saver, hard or soft fade digit change, and even have a built-in "Slot Machine" cathode poisoning prevention routine. Programming and setting the clock is a breeze with simple 2-button entries on the rear panel. The clocks are available in our signature hand rubbed Teak & Maple, polished aluminum, or clear acrylic bases.

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Create your own lightning with these time tested student favorites! Produces low current static currents that can be "shocking" but perfectly safe! Draw sparks to a screwdriver, grab hold and watch your hair stand straight up! Two models produce from 200kV to 400kV!

VG Van de Graaff Generators from \$139.95

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MC1 Mini Electret Condenser Mic Kit \$3.95

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Measure RF with your standard DMM or VOM! This extremely sensitive RF detector probe connects to any voltmeter and allows you to measure RF from 100kHz to over 1GHz! So sensitive it can be used as a RF field strength meter!

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